Volume XLII Number 1

ANNALS

OF

The Entomological Society of America

MARCH, 1949

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PUBLISHED QUARTERLY BY THE SOCIETY
COLUMBUS, OHIO

Entered as second-class matter April 11, 1908, at the Post Office at Columbus, Ohio, under the act of Congress of March 3, 1879. Subject to rate of postage provided for in Paragraph 4, Section 538, P. L. & R., authorized September 16, 1940.

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ANNALS

OF

The Entomological Society of America

Volume XLII MARCH, 1949 No. 1

THE CLASSIFICATION OF INSECTS[1]

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The living organisms that inhabit the earth in colossal numbers are incomprehensible to us either as a whole or in part unless they are arranged or classified in some sort of systematic way. It is not surprising then to find that attempts to classify the living world extend far back into the distant past and that our present classifications are the result of a long period of growth and development. The earliest ideas regarding classification of which we have any record are those of Aristotle (384–322 B. C.). He did not concern himself with formulating any definite outline of classification, but as one reads his written works it is evident that he had definite ideas regarding the systematic arrangement of the living things known to him. With reference to the insects he recognized and differentiated between the wingless ones and those with wings. He undoubtedly included many animals among the wingless insects that we do not consider as insects today. Among the winged insects he recognized distinct groups, some of them comparable to our orders of insects, on the basis of the number of wings, texture of wings and vestiture of wings.

Aristotle's written works were regarded as an infallible source of knowledge of natural history for centuries. It was not until after the invention of printing and the revival of learning in the middle ages that any new contribution was made. One of the first attempts to give a complete account of the insects was a book by an Italian Professor, Ulysses Aldrovandus (1522–1607). His book on the insects, "De animalibus insectis libri septem," was published in 1602. At the beginning of this book there is an outline which sets forth Aldrovandi's proposals regarding classification of the insects. He did not use the presence or absence of wings, nor the characteristics of the wings as the primary basis for arrangement and definition of groups. His first division separated insects into two ecological groups, those terrestrial

[1]Paper No. 2415, Scientific Journal Series, Minnesota Agricultural Experiment Station, St. Paul 1, Minnesota.

and those aquatic. Each of these was further subdivided on the basis of legs present or absent, and if present, the actual number of legs. Finally the number and nature of the wings were taken into account. Undoubtedly the lack of emphasis on wings and their nature as insect characteristics was due to the fact that the term "insects" was an exceedingly broad one and included many animals not considered by us as insects. Crustaceans, molluscs, worms, starfish and even the sea horse (a fish) were all included in this book on insects and were so defined by him.

Aldrovandi's book was the standard reference work for one hundred years or more and during this period Swammerdam (1637–1680) made his famous studies on metamorphosis. Swammerdam, in a book entitled "Historia insectorum generalis" published in 1669, suggested that metamorphosis might serve as a primary basis for the classification of insects and that four groups of insects could thus be recognized. He did not, however, propose any formal classification.

John Ray (1628–1705) and Francis Willoughby (1635–1672) working in England attempted to apply Swammerdam's ideas to insect classification, although Willoughby died many years before the results of their work were published. Ray's classification was published in "Methodus insectorum, etc." in 1705. The four kinds of metamorphosis suggested by Swammerdam were used as the primary divisions and Aldrovandi's classification was added to this almost unchanged. The term "insects" was still used in the same broad sense as it had been used by Aldrovandi, and included many invertebrate animals that are today arranged in other classes and phyla.

Two years after Ray's death Linnaeus (1707–1778) was born in Sweden. He was destined to influence and change the whole course of natural history to a greater extent than anyone since the time of Aristotle. He introduced and established the system of binary nomenclature, reducing the long Latin phrases which had previously been used for names of animals and plants to two Latin words, a generic name and a specific name. He introduced definite categories or ranks into the classification of organisms. Thus, genera were composed of species, orders were made up of genera, a class included one or more orders, and a kingdom was subdivided into classes. The insects were given the rank of a class.

Linnaeus made two distinct advances in the classification of the insects which laid a foundation for further advancement and improvement. First, the definition of the class Insecta was limited so that many of the invertebrate animals formerly regarded as insects, such as molluscs, worms, etc., were removed to other classes; second, the elimination of many of these non-insect animals left Linnaeus free to formulate a classification of the insects on the basis of their unique and most characteristic structures, the wings. The idea was not new, it had already been suggested by Aristotle two thousand years before, but Linnaeus sensed its fundamental nature, resurrected it and applied it anew. His class Insecta was made up of seven orders: the Aptera, without wings; the Diptera, with two wings; two orders with four

membranous wings, the Hymenoptera with a sting (ovipositor), and the Neuroptera without a sting; the Lepidoptera, with four wings imbricated with scales; the Hemiptera, with four wings, the front pair semicrustaceous; and the Coleoptera, with four wings, the front pair crustaceous.

The innovations of nomenclature, systematic ranking and classification introduced by Linnaeus were a tremendous stimulus to the study of natural history because they facilitated thinking, talking and writing about the objects of natural science. The tempo of investigation and discovery was greatly increased and the number of known species of animals and plants multiplied by leaps and bounds.

Linnaeus was a great teacher as well as a great naturalist. Students traveled to Upsala, Sweden from all parts of Europe to study with him. Among these students was one, John Christian Fabricius (1742–1808), who was primarily concerned with entomology. He spent two years with Linnaeus and then returned to Denmark where he published a long series of taxonomic works on the various orders of insects. Fabricius was greatly impressed with the structure of the mouth parts of insects and proposed a system of classification based entirely on the maxillae. His class Insecta was made up of thirteen orders, four of which included Crustacea, Myriapoda and Arachnida. The nine others included insects, in the strict sense, and were the same as the Linnaean orders, except that two additional ones were included, the Orthoptera and Odonata.

Linnaeus had based his system of classification of the insects on wings and indicated the fact by using ordinal names expressing the wing characters, thus: *lepido* = a scale, *pteron* = wing; Lepidoptera = scaly winged insects. Fabricius followed the same custom and gave all his orders new names which expressed the maxillary characters used. He selected the Greek word *gnatha* = lower jaw, to refer to the maxillae and combined it in modified form with various prefixes to form ordinal names, thus: *kleistos* = closed, *gnatha* = jaw: Kleistognatha, for certain Crustacea; *odous* = tooth, and *gnatha:* Odonata for the dragonflies; and *piezo* = to press, and *gnatha:* Piezata for the Hymenoptera. The mouth parts are undoubtedly one of the important sets of structures upon which insect classification is based, but they are only one of many characters which must be considered. It is not strange, therefore, that Fabricius' classification did not survive for it had a still narrower basis, the maxillae. Since the classification did not survive, neither did the names and all have fallen into the discard, except Odonata for the dragonflies.

The deficiencies of both the Linnaean alary system and the Fabrician maxillary system served to emphasize the point that a natural classification cannot be based on a single morphological structure, but at the same time each of them focused attention on a single set of structures which were of fundamental importance and neither of which could ever be ignored in the future in insect classification. Both Linnaeus and Fabricius were popular among the scientists and naturalists of their day, Linnaeus particularly popular with the botanists and

Fabricius with all those interested in entomology. The work of both was a great stimulus to the study of natural history and gave tremendous impetus to the study of insects.

The restriction of the class Insecta to animals with three distinct body regions, three pairs of legs, and usually two pairs of wings was brought about by Latreille (1762–1833) at the suggestion of Cuvier (1769–1832). The Crustacea were proposed as a class by Latreille in 1806–07 in "Genera Crustaceorum et Insectorum, etc.," the Arachnida in 1810 in "Considerations generales—les classes des Crustaces, des Arachnides et des Insectes, etc.," and the Myriapoda in 1825 in "Familles naturelles du regne animal." Latreille gradually modified the Linnaean and Fabrician systems of classification so that by 1831 he recognized four classes, Crustacea, Arachnida, Myriapoda and Insecta, with the latter arranged in twelve orders. His classification was based on wings, mouth parts and metamorphosis, a combination of the ideas of Swammerdam, Linnaeus and Fabricius.

Cuvier also suggested a new category to be placed between the order and the genus, and termed it the family. Latreille accepted and applied this suggestion to the insects, the category family being used in all his published works beginning with that in 1806–07 cited above.

Charles Darwin's "Origin of species" appeared in the year 1859. The implications of the theories of evolution and natural selection began from that time to penetrate all fields of biological thought. This was especially true of classification or taxonomy because Darwin's book dealt directly with the primary problem of the taxonomist—How do species come about in nature? One of the earliest manifestations of the influence of Darwin's theories on classification was the invention of family tree diagrams by Haeckel in 1866 to illustrate phylogenetic lines of descent, and his introduction of a new category, the phylum, intermediate between kingdom and class. The impact of Darwinian thought on insect classification was undoubtedly more or less immediate, but the first results were not evident until 1885.

Twenty-six years after the publication of the "Origin of Species" Friedrich Moritz Brauer (1832–1904) published an essay in 1885 "Systematische-Zoologische Studien" in which he proposed a new classification of insects. This work is a milestone in the history of insect classification. It separates sharply two entirely different modes of thought and approach to the problems of insect classification. The predominating thought underlying all attempts to formulate a classification of insects had been that some single morphological structure could be found that would reveal a natural system (the idea of the Creator) of classification. With Swammerdam, it was metamorphosis, with Linnaeus it was undoubtedly the wings of insects, and the mouth parts, or strictly speaking, the maxillae, were the revealing character to Fabricius. Latreille used a combination of all three. Beginning with Brauer the objective has been to formulate a classification of insects in accord with phylogenetic principles, one which would take into account all the morphological structures of the insect and their modifications, and interpret them in the light of evolutionary theory.

Brauer based his classification on a number of characters: (a) presence or absence of wings; (b) number of Malpighian tubules; (c) metamorphosis; (d) mouth parts and their changes during ontogeny; (e) nature of the wings; (f) relative development of the thoracic segments. He arranged the insects in two subclasses. The Apterogogenea included those insects which are wingless and which have probably descended from ancestors that never had wings. This class had only the one order, Synaptera, the most primitive and presumably oldest insects. It included both Thysanura and Collembola. All other insects were placed in the subclass Pterogogenea, the winged insects, or if wingless at the present time, they have descended from ancestors that once had wings. This subclass was made up of sixteen additional orders of insects. Using the morphological criteria he had set up for a guide, he arranged these sixteen orders in a series beginning with the most primitive, the most generalized and the oldest geologically, and terminating with the most specialized and recent.

Brauer's system forms the basis for all modern classifications of insects. His system has been modified by various authors in different ways. The number of orders recognized in each subclass has been increased. The greatest changes have been made in the Pterogogenea as the result of attempts to express the phylogenetic relationships of the various orders more satisfactorily. Two fields of research have contributed greatly to modern views regarding the phylogeny of insects, the tremendous advances in our knowledge of fossil insects made by Scudder, Handlirsch, Tillyard and Carpenter, and studies in comparative morphology by Comstock, Crampton and many others. Probably no period in the world's history has seen as many new facts added to our knowledge of insects as that from Brauer's time until the present, yet the fundamental features of his insect classification are still considered valid. The modifications which have been made only add to its value and increase the scope of its usefulness, but have not introduced any new fundamental conceptions on which some entirely different type of classification could be based. The principal modifications have been proposed by Comstock (1895, 1910, 1924), Sharp (1898), Handlirsch (1906, 1925), Brues and Melander (1915, 1932), Crampton (1922, 1928, 1938), Martynov (1923, 1925), Imms (1925) and Tillyard (1926).

The system of classification adopted here is modified from the proposals of Martynov and Crampton. It has been chosen because it appears to reflect the phylogenetic development and relationships of the winged insects as accurately as our entomological knowledge permits. The principal differences from that of Brauer's system are: 1. The recognition of the Paleopterygotan insects which cannot fold their wings over the abdomen in repose as more primitive and older than the Neopterygota which fold their wings over the abdomen in repose, first proposed by Martynov and Crampton independently; 2. The grouping of certain orders in superordinal complexes to indicate close phylogenetic affinities, as proposed by Crampton; 3. The recogni-

tion of many more orders; and 4. A different linear arrangement of orders to express better phylogenetic relationships.

SYNOPSIS

Phylum ARTHROPODA
Class INSECTA
Subclass APTERYGOTA
Order 1. PROTURA
" 2. THYSANURA
" 3. COLLEMBOLA
Subclass PTERYGOTA
PALEOPTERYGOTA
Order 4. EPHEMEROPTERA
" 5. ODONATA
NEOPTERYGOTA
Heterometabola
Isopteroid Insects
Order 6. BLATTARIAE
" 7. MANTODEA
" 8. ISOPTERA
Plecopteroid Insects
Order 9. PLECOPTERA
" 10. EMBIIDINA
Orthopteroid Insects
Order 11. ORTHOPTERA
" 12. PHASMIDA
" 13. DERMAPTERA
Psocopteroid Insects
Order 14. CORRODENTIA
" 15. MALLOPHAGA
" 16. ANOPLURA
Hemipteroid Insects
Order 17. THYSANOPTERA
" 18. HEMIPTERA
" 19. HOMOPTERA
Holometabola
Coleopteroid Insects
Order 20. COLEOPTERA
" 21. STREPSIPTERA
Neuropteroid Insects
Order 22. NEUROPTERA
" 23. MECOPTERA
" 24. HYMENOPTERA
" 25. DIPTERA
" 26. SIPHONAPTERA
" 27. TRICHOPTERA
" 28. LEPIDOPTERA

A NOTABLE AGGREGATION OF COLLEMBOLA[1]

ORLANDO PARK
Northwestern University

In general, podurid and entomobryid springtails and oribatid mites are the most abundant arthropods in the litter of the forest floor and are important in the overall formation of organic soil (Allee, Emerson, Park, Park and Schmidt, 1949). On occasion, certain species of springtails have been reported as forming aggregations of almost incredible numbers of individuals. Elton (1927, p. 109), for example, states that swarms of collembolans are said to have held up a Swiss train, the minute insects covering the rails so heavily that the driving-wheels of the locomotive revolved ineffectually.

The most circumstantial accounts of such aggregations known to the author are those described by Macnamara (1919) in Ontario, and one of these, in particular, will be referred to presently.

The purpose of the present paper is to describe quantitatively an aggregation of *Achorutes*. At 10:30 a. m., December 7, 1946, a workman, Adam Rokocinski, noticed a "lot of pinkish bugs" pouring from a small hole in the sod of Dyche field on the University campus. There were three such holes in an area of six square feet, from all of which the insects were emerging. A small pile of soil at the lip of one hole and about one-third of the clustered "bugs" at this orifice were put in a can and brought to the author. The insects were stated to have gone down the holes "like ants" about 3:00 p. m. of the same day.

Examination of the container demonstrated very large numbers of Collembola (Fig. 1). The soil fraction weighed dry was 59.006 grams. The springtails were measured volumetrically in alcohol, in a graduated cylinder of 5 c.c., calibrated to tenths c.c. A sample of 25,000 was counted, and measured 1.92 c.c. in the cylinder. The whole collembolan fraction measured 35.44 c.c. This whole fraction was obtained by measuring thirteen additional samples in the small cylinder, and adding the samples to avoid undue packing of the insects in the cylinder, which might introduce too great an error.

The following populations were estimated on the basis of the counted sample of 25,000, and then checked against a second counted sample of 8,000. It was estimated that the 59.006 grams of dry soil held a minimal population of 450,000 springtails. This is a conservative figure, since it does not take into account great numbers of individuals that were lost in picking up the initial sample, and which might bring the total to 600,000 or more as noted in an advance abstract (Park, 1947).

[1]I thank Dr. Harlow B. Mills, Illinois Natural History Survey, for the identification of the material; Dr. Eliot C. Williams, Jr., Wabash College, for the photograph; Miss Marie Wilson, Northwestern University, for the drawing; and Mr. Lawrence Jones, Northwestern University, for assistance in counting samples of the population.

On the basis of the estimate of 450,000 collembolans in the sample, this would give a conservative population of 1,350,000 per exit hole, and for the three holes in an area of six square feet, the minimal population would be 4,050,000. At the time the sample was collected the author was away, and the opportunity was lost to study this large aggregation in the field.

No collembolans were found on the following day, or for several days afterwards. They appeared to have vanished and the search was stopped. The three exit holes appeared to belong to abandoned burrows of the local ground squirrel, *Citellus tridecemlineatus*. An

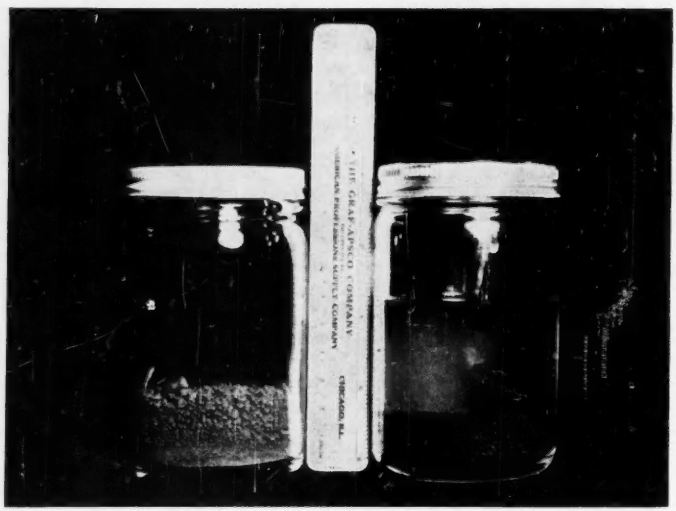

FIG. 1. Photograph of the sample. Jar at left holds the soil fraction of about 59 grams, dry weight. Jar at right holds about 450,000 collembolans.

explanation of the aggregation is that the nest materials and food scraps of the rodents formed an excellent source of nourishment for the initial springtail immigrants. In time, this decomposing herbaceous mold would be eaten by the rapidly increasing population, and the insects would emigrate from the burrows.

This general explanation was offered by Macnamara for eruptions of *Achorutes socialis* and its congeners (l.c., p. 269) with the exception that the springtails were said to have continued to spread from the overcrowded habitat niche until it was wholly abandoned. In the present instance the insects were stated by the workman to have returned to the burrows in the afternoon. This is possible, but the author feels that the latter observation may have been misinterpreted; that, instead,

the collembolans continued to mill about the holes and to move away. If so, the population density must have been much larger than estimated, possibly on the order of 9,000,000 per square meter in the immediate vicinity of the exit holes.

These collembolans were identified tentatively as *Achorutes bengtssoni* Agren (Fig. 2). As noted by Dr. Mills, this is a European species seen only once previously by him from North America. In Europe this species is found in the north and under Alpine conditions farther south. Many springtails have a holarctic distribution and this record of *bengtssoni* in northern Illinois appears to exemplify this principle.

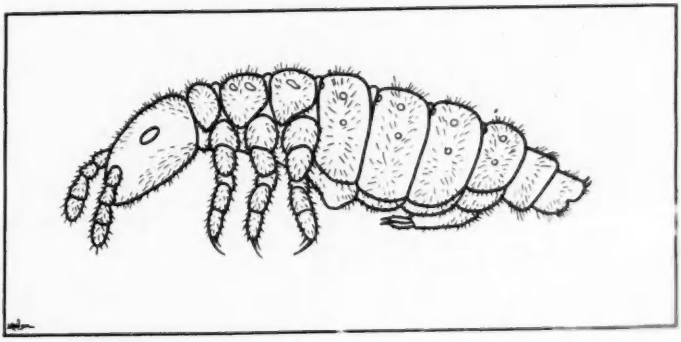

FIG. 2. Left lateral aspect of *Achorutes bengtssoni* Agren.

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Macnamara, Charles. 1919. Remarks on Collembola. Canadian Entomologist, 51: 73–80, 241–245, 265–271. 2 pls.

Park, Orlando. 1947. A notable aggregation of Collembola. A. A. A. S., Chicago. Bull. Ecol. Soc. Am., 28(4): 60–61.

PRESERVATION OF GRAINS IN STORAGE, by STEPHEN S. EASTER (Editor). FAO Agric. Studies No. 2, iv+174 pages, 4 charts, 2 figs. 1948. Price, $1.50.

This volume consists of a series of seventeen papers presented at a meeting of the Food and Agriculture Organization of the United Nations in London, England, during August, 1947. Four of these deal specifically with insect pests of stored grains, another considers the need for research on stored grain insect problems, and several others deal partly with the entomological phase of the subject. The volume treats the problem of stored grain pests from an international standpoint; consequently, the entomological aspects of international commerce involving grains is considered.—M. T. J.

SOME NEW AND POORLY KNOWN THEREVIDAE (DIPTERA) FROM COLORADO

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This paper is presented in order to describe a new species of *Psilocephala* and to clarify the status of the species of the *pygmaea* group of *Thereva*.

Psilocephala montiradicis n. sp.

Male.—Head black. Frons except lower angles shining; a subshining area clothed with short stiff yellow pile immediately below each eye; head otherwise whitish pollinose with silky white hairs. Bristles of occiput mostly yellow; some black setulae on occiput above. Eyes broadly contiguous. Ratio of antennal segments 11: 4: 15; flagellum gradually tapering to its style; scape with bristles and bristle-like hairs, most of which are black; pedicel and basal third of flagellum except on its outer face with black bristle-like hairs. Proboscis black with whitish pollen and silky whitish hairs.

Thorax black; mesonotum brownish pollinose, the pollen more whitish on notopleura and above wing bases; a pair of whitish vittae extending from neck to base of scutellum; scutellum whitish pollinose laterally and apically, brownish at base, subshining at extreme apex; pleura whitish pollinose. Pile mostly silvery whitish; that of mesonotum sparse, with sometimes a few blackish hairs; bristles black.

Coxae black, whitish pollinose; trochanters and femora black, their extreme apices reddish yellow, their pile yellowish, appressed, but some, especially ventrally, silky, whitish, erect; tibiae reddish yellow, approximately the apical third of front pair and extreme apices of middle and hind pair blackish, bristles and most hairs black; front tarsus blackish; middle and hind tarsi brownish, their basitarsi and sometimes second segments reddish yellow; tarsal hairs black. Wings whitish, subhyaline, stigma and veins brown, veins yellowish toward base; vein R_4 moderately sinuous; cell M_2 closed and petiolate. Halteres blackish, stems yellowish-brown.

Abdomen black; pregenital segments wholly densely whitish pollinose and with silky whitish hairs; ninth tergum blackish, lightly whitish pollinose; ninth sternum subshining, mostly blackish, broadly divided to base ventrally, each part with two apical lobes which become reddish yellow, the upper bearing a tuft of long straight yellowish hairs; genitalia otherwise reddish yellow; forceps (fig. 1) somewhat boot-like, with apex acute; pile of genitalia mostly yellow to whitish, two to four yellow to black bristles on each side at lower corners of ninth sternum.

Length, 7–9 mm.

Female.—Frontal callus shining black, not quite reaching ocellar triangle, the upper part of frons transversely wrinkled; face, a triangle at each lower corner of front, and occiput whitish pollinose; ocellar triangle, vertex, and front above callus subshining, becoming whitish pollinose laterally; two to five black setae in a row on front on each side above callus; stiff hairs of subshining spot below cheek black. Vertex, front at antennal bases, and head width in ratio of 11 : 26 : 50. Thoracic pile shorter than in male and with more short black pile dorsally. Tibiae usually more broadly black apically than in male, sometimes entirely black. Wing veins broadly margined with brownish; costal and marginal cells mostly brown. Abdomen shining, becoming subshining laterally and ventrally and whitish pollinose ventrally at base; blackish, apex of second tergum yellowish; with scattered appressed yellowish hairs and with short erect black hairs from second sternum and third tergum on. Length, 7–9 mm.

Holotype, male.—Fort Collins, Colorado, May 2, 1940 (M. T. James); Colorado A.&M. College Collection. *Allotype*, female.—Fort Collins, Colorado, May 23, 1941 (James). *Paratypes.*—Fort Collins,

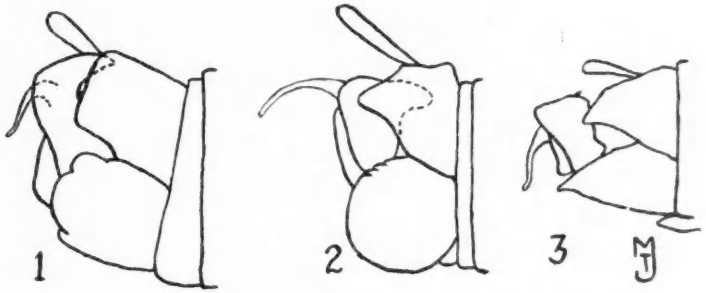

FIG. 1. Male genitalia, in outline, lateral view, of *Psilocephala montiradicis*.
FIG. 2. Same of *Thereva xanthobasis*.
FIG. 3. Same of *Thereva pygmaea*.

Colorado, June 15, 1937 (M. T. & H. B. James), June 2, 1939, May 2, 1940, May 23, 1941, and June 3, 1941 (all M. T. James), 5 males, 5 females.

Some variations appears in specimens of the type series. Freshly emerged individuals have a greater amount of soft pale pile. One male paratype has the front tibiae wholly black and the pile on the subshining spot below the eyes blackish.

In Cole's keys the female traces to *P. costalis* except that the bases of all tibiae may be reddish; the male traces to ***argentifrons*** but the frons is largely shining, at least the middle and hind tibiae are largely reddish yellow, and the genitalia are largely reddish, shorter and more compact, and structurally quite different.

Thereva xanthobasis n. sp.

Male.—Head black, wholly whitish pollinose, pollen sparse on front so that this area, except laterally, appears subshining. Pile of vertical triangle, frons, and upper part of facial orbits black, that of frons almost as long as antennal scape and pedicel combined; pile of above areas mostly stiff and more or less bristle-like, that of face becoming whitish and more silky; that of cheeks, proboscis, and occiput whitish and silky; occipital bristles short, mostly pale, a few black ones above. Antennal ratio 12: 3: 6; scape and pedicel with black hairs and bristles, the former sometimes with a few pale ones below at base; flagellum pear-shaped, a few black setulae near its base.

Thorax black, wholly whitish pilose and almost entirely whitish pollinose; two rather poorly defined dorsal vittae of denser, somewhat more yellowish pollen; usual bristles black. Legs mostly black; middle and hind tibiae except apices, fore tibia on basal third to half, and middle and hind basitarsi except apices yellowish; coxae whitish pollinose, femora less densely so; pile of coxae and femora whitish and silky as on thorax, that of tibiae and tarsi short, black. Halteres reddish brown, knobs somewhat darker. Wings hyaline; veins yellowish on basal half, becoming darker apically; vein R_4 moderately sinuate; cell M_2 closed in margin or short petiolate.

Abdomen black; pregenital segments wholly silvery pollinose and whitish pilose; genitalia short, robust; ninth tergum except apex, ninth sternum, and upper outer part of outer forceps blackish, thinly whitish pollinose; pile and bristles of genitalia whitish. Ninth sternum divided into two almost semiglobular lobes; ninth tergum becoming thin and yellowish on upper apical margin, its apex prolonged into a digitate process; outer forceps boot-like in outline.

Length, 6–6.5 mm.

Holotype, male.—Fort Collins, Colorado, October 8, 1931; Colorado A. & M. College Collection. *Paratypes.*—Fort Collins, Colorado, September 26 and August 10, 1931, 2 males.

This is a *Psilocephala*-like species, of the *Thereva pygmaea* group. In Cole's key it runs to *melanoneura*, from which it may be distinguished by the characters given in my key and by the quite different structure of the male genitalia (fig. 2).

Thereva pygmaea Cole

Thereva pygmaea Cole, 1923, Proc. U. S. Nat. Mus., 62: 89–91.

Cole does not describe the genitalia of this species and his illustration does not show the structure in sufficient detail. Moreover, the true nature of the thoracic pollen is not indicated. The following notes, which should facilitate identification and indicate more exactly the range of variation, were based on a series which I at first thought to be a new species. I am indebted to Mr. Curtis W. Sabrosky, Division of Insect Identification, Bureau of Entomology and Plant Quarantine, for comparing a pair of my specimens with the types of *T. pygmaea* and for the loan of a pair of paratypes of that species, by means of which

I was able to corroborate his conclusions as to the identity of the two supposed species.

Male.—Mesonotum shining black only posteriorly, laterally, and on and near humeri, otherwise densely brown pollinose except for two distinct whitish longitudinal vittae; from posterior view the brownish pollen appears golden brown, with some lavender intermixed; mesonotal pile mostly long, whitish, with some fine black pile interspersed. Scutellum silvery-pollinose except at base. Abdomen black, for the most part densely silvery-pollinose, sides of second to fifth segments inclusively shining on anterior half or more of the segments laterally; sterna except first subshining basally. Ninth tergum blackish, the lateral lobes acute, becoming yellowish-red toward apices; ninth sternum broadly divided into two acute lobes which become yellowish-red toward apices; genitalia otherwise reddish-yellow; outer forceps (fig. 3) large, the apical part broadened, a small black thorn-like protuberance near the upper anterior corner; pile of ninth segment mostly as on pregenital segments, but a few black setulae on the tergum and some long slender black and whitish bristles on the sternum; outer forceps with a tuft of yellow hairs at upper posterior corner, otherwise with mostly black and a few yellow hairs. Length, 6–7 mm.

Female.—Mesonotal pollen except laterally and on the two longitudinal vittae wine-red to lavender, the color evident only from a posterior view. Length, 6–8.5 mm.

Material studied.—Irish Canyon, south of Sparks, Moffat County, Colorado, June 25, 1946 (M. T. James), 8 males, 6 females; Phillipsburg, Jefferson County, Colorado, July 3, 1947 (James), 1 male.

KEY TO THE MALES OF THE *T. pygmaea* GROUP

1. Wing with two brown cross-bands..... **anomala** Adams
   Wing hyaline.....2
2. Abdomen with shining areas laterally on each of segments two to five; front legs wholly black..... **pygmaea** Cole
   Abdomen entirely gray or whitish-pollinose laterally; front tibia yellow at least basally.....3
3. Mesonotal pile in part black; wing veins black..... **melanoneura** Loew
   Mesonotal pile wholly pale; wing veins yellow toward base.. **xanthobasis,** n. sp.

INTRODUCTION TO APPLIED ENTOMOLOGY, by WILLIAM J. BAERG. vii+191 pages, 208 figures. Burgess Publishing Co., Minneapolis 15, Minnesota. 3rd revised edition. 1948. Price, $4.00.

The primary objective in Baerg's recent edition is "to acquaint the student with the more common insects, some spiders and scorpions, as well as a few mites and ticks." A relatively thorough discussion is presented on the various classes of arthropods, which is too often slighted in similar texts. The insects under discussion are discussed according to their systematic position, rather than by crops or hosts. The advisability of such an arrangement is always debatable.

In view of the recent advances in insecticides, perhaps more emphasis should be placed on the newer compounds. The illustrations for the most part are good. Recent or more important references on the economic pests treated are listed. Certainly, this work will be well received by instructors charged with the teaching of general courses in economic entomology.—H. S. TELFORD.

AN INSECT RESPIROMETER

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In the course of some studies on house flies, it became desirable to determine the respiratory exchange of individuals. Since the metabolism of such insects is low, a fairly sensitive apparatus was required. Existing micro-respirometers were not well adapted for use with whole active insects, consequently the apparatus described herein was constructed.

APPARATUS

The constant pressure principle was adopted as the basis for this respirometer, shown in figure 1, as it permitted simple construction and operation. It is similar to the apparatus of Kalmus (1928) except that the size is greater. The apparatus was constructed from a brass block, as were the differential or Barcroft type respirometers of Cunningham and Kirk (1940), Barth and Kirk (1942), and Crisp and Thorpe (1947). This construction is advantageous since the low heat capacity and high conductivity practically eliminate zonal temperatures.

Round stock was used in making this model; however the shape of the block is not critical. A flat surface, 1¼ inch wide, was machined on the bar, and five wells, ½ inch in diameter and ½ inch deep, drilled through this surface. These served as the respiration chambers. Smaller wells, ¼ inch in diameter, were drilled perpendicular to the first set to hold the index capillaries. Small holes, 1/16 inch in diameter, connect the respiration chamber and index capillaries.

The ¼ inch wells were threaded to accomodate brass sleeves into which the index capillaries were sealed with tempered shellac. This arrangement held the capillaries rigidly and still permitted them to be exchanged for others. Where a capillary was not level when installed, it was adjusted in place by bending the glass after it had been heated with a hand torch. It was also found adequate to seat the capillaries directly into the respirometer block. In this case, rubber bands were used to hold the tube against lightly greased rubber gaskets. A support was required at the distal ends of the capillaries to keep them level.

Index capillaries were prepared from ordinary thick walled stock of the appropriate diameter (0.3–1.0 mm.). The distal end was blown out and fire polished to facilitate insertion of an oil index droplet. The capillaries were calibrated with mercury, and the bore checked as to uniformity by measuring the length of the mercury droplet at several points. The volume calibration is most conveniently expressed as λ /cm. ($1\lambda = 1$ microliter $= 1$ cubic millimeter) and may be used directly

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as a volume factor in calculations. A reading scale made of millimeter paper was attached to each tube by means of "Scotch Tape."

The screens separating the insect from the hydroxide were made of 70 mesh brass, and were mounted on rings cut from (½ inch) copper tubing. Large squares of screen were "tacked" to the ring with solder, then trimmed with a motor driven wire wheel. This not only removed excess screen, but also fused the brass and copper. Excess solder was removed by heating in a flame and shaking it out.

Hydroxide holders were prepared by closing and flattening one end of a piece of glass tubing of the proper diameter (5–10 mm.) and cutting it at the appropriate length. These holders could all be adjusted to the same glass volume by adding or removing glass to bring them to the same

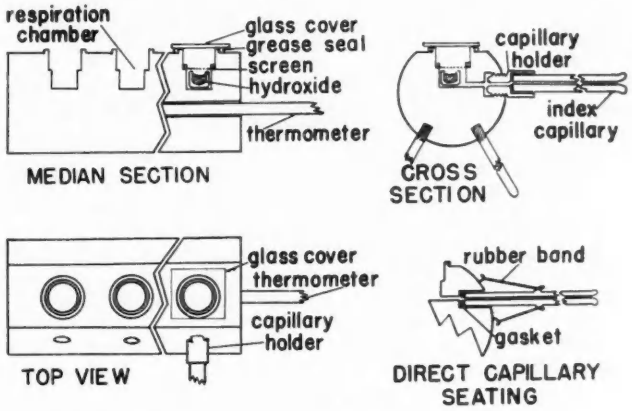

FIG. 1. Construction details of an insect respirometer.

weight. A standard amount of 10% sodium hydroxide was pipetted into each holder to absorb the carbon dioxide.

Glass covers used for the individual chambers were cut from microscope slides. These permitted observation of the test material and the grease seal. Since glass has a low heat conductivity, heat transfer through the cover was negligible. Covers were sealed to the block with petrolatum which was applied with a Luer syringe. A thick layer was applied outside the chamber rim, thus when the cover was in place, none of the grease entered the chamber.

Temperature of the block was measured with a thermometer which was inserted in a hole drilled horizontally. Thermoregulation could be established by either an air or water thermostat. In the latter case, only the lower part of the block was immersed. In most cases, however, ordinary room conditions were sufficiently stable to permit satisfactory determinations, provided the temperature was at the desired level. Metabolic effects of temperature differences are correctable by thermal coefficients which can be calculated after a few trials at different tem-

peratures. In the case of flies, these factors may be taken from the work of Batelli and Stern which has been summarized by Wigglesworth (1939).

PROCEDURE

Prior to a trial, the assembled respirometer was equilibrated with the environment for a period of an hour. Flies were chilled at 4°C, which rendered them comatose and easy to handle. This could be accomplished either by placing a cage of flies in a cold room, or by catching a few in a test tube and immersing it in ice-water. For metabolic studies, this method is superior to treatment with ether or other chemicals where residues of the anaesthetic may have a physiological effect.

Individual flies were weighed to 0.2 mg. (on a Roller-Smith torsion balance) and installed in their respective respiration chambers. One chamber was left as a blank or thermobarometer, and used to correct observed results for barometric and thermal changes. The rims of the chambers were then greased and covers put in place. The gas composition in the respiration chamber can be changed by directing a stream of the desired gas (oxygen for example) into the chamber during the closing process.

When the chambers had been closed, the index oil droplet was installed with a finely drawn pipette. Kerosene was used for this purpose, being treated as recommended by Schmitt (1933) to remove resinous residues. The drop could be placed directly in the calibrated portion of the capillary, or it could be drawn in from the end after briefly touching the cover glass with a hot object (such as the glowing end of a cigarette). In cases where the respiratory exchange was rapid, such adjustment was unnecessary except in the thermobarometer. Proper sealing of the individual chambers was tested either by pressing on the cover glass or by blowing sharply toward the open end of the capillary. In a satisfactory preparation the droplet is displaced, but readily returns to its original position.

Readings of the index droplet position were started ten or fifteen minutes after the assembly of the apparatus, and were continued at fifteen minute intervals. A total period of one hour was usually sufficient for a trial. Interruption of the trial to treat the insects was readily accomplished. The adult animals were caught in a test tube which was held over the mouth of the chamber as the cover was removed. The tube, plugged with cotton, was then immersed in ice water to immobilize the insect.

At the termination of the trial the insects were removed and the apparatus cleaned. If the animals had been treated with any toxic material (such as DDT) residues were removed with an appropriate solvent. Between trials, the apparatus should be stored in such a position as to permit drainage of the capillaries.

CALCULATIONS

Calculation of the volume of oxygen consumed is simple, since it is proportional to the displacement of the index droplet after it has been corrected for thermal and barometric changes. The thermobarometer

correction is most conveniently made on a linear basis. This results in an error when there are cross-sectional differences between the capillaries. When the thermobarometer change is relatively small, however, this error is negligible. For example, the inaccuracy from this short-cut would be only 1% when the respiration change is tenfold greater than the thermobarometer change, even though the capillary volume factors may differ as much as 10%. When the thermobarometer change is relatively great, however, it should be multiplied by the ratio of the

TABLE I

TRIAL WITH HOUSE FLY LARVAE (26 SEPT., 1947)

Chamber No.	Droplet Position (cm.) at indicated time				Droplet Displacement (cm.) (corrected with thermobarometer)			
	1530	1545	1600	1645	¼ hr.	¼ hr.	¼ hr.	av.
1	0.70	1.34	1.90	2.47	0.77	0.69	0.64	0.70
2	1.07	1.90	2.69	3.46	0.95	0.92	0.85	0.91
3	1.73	1.60	1.47	1.40	(the	rmobar	ometer)	
4	0.75	0.80	0.92	0.97	0.18	0.25	0.12	0.18
5	1.00	3.28	5.00	6.48	2.41	1.85	1.55	1.94
t (°C.)	28.00	28.02	28.08	28.10				

Chamber No.	Volume Factor (λ/cm.)	Oxygen Cons. * (λ/hr.)	Larval Weight (mg.)	$Q^1 O_2$* (λ/mg./hr.)
1	6.0	14.6	10.0	1.5
2	6.5	20.6	10.5	2.0
4	6.0	3.7	11.0	0.4
5	6.6	44.5	25.8	1.7

(*Calculated to standard conditions.)
Barometer: 762 mm. Hg.
Conversion factor (to standard conditions): 0.87.

thermobarometer capillary volume factor to that of the respiration capillary before being used as a correction.

The formula for calculating the gas volume change in a respiration chamber is as follows:

(cm. respiratory change − cm. thermobarometer change) × volume factor = oxygen consumption

The volume of oxygen consumed can be reduced subsequently to standard conditions (dry, 0°c., 760 mm. Hg. pressure) according to the gas laws. For this calculation, the gas may be considered as saturated with water vapor.

The protocol of an actual trial with house fly larvae is given in table I. The increased oxygen consumption noted in the first period is a result of increased activity of the animal. It is absent with pupae and more pronounced with adults. It can be reduced by lengthening

the preliminary period. The larva in chamber 4 was in a pre-pupal stage, which accounts for the low rate of oxygen consumption observed. These data are in agreement with those of Batelli and Stern, who found the oxygen consumption of fly larva at 28°C. to be 2 λ O_2/ mg./ hr. and of fly pupa, 0.1 λ O_2/ mg./ hr.

DISCUSSION

The apparatus described furnishes a rapid and simple means of determining the respiratory exchange of insects. It has been found convenient and useful in physiological studies of insects. Its design is such that its fabrication is inexpensive. The theoretical basis of this (constant pressure) type of respirometer is the simplest of manometric respirometers (Dixon, 1943). With the index drop directly measuring the volume change, this apparatus is well suited to studying insects of house fly size. For much smaller measurements, a more sensitive apparatus, such as the differential respirometers previously mentioned, is preferable. For much larger measurements, a more elaborate system of carbon dioxide absorption and volume measurement is required, simple diffusion and capillary volumes no longer being sufficient. On the present scale, carbon dioxide absorption is rapid and adequate. This is tested roughly by exhaling into a chamber, after which it is sealed and absorption followed by means of the index drop. The process is completed in about thirty seconds.

As has been previously noted, volumetric calibration of the chambers is unnecessary. In some cases, however, where differences in chamber volumes exist, and environmental conditions cause large thermobarometer changes, the chamber volume must be taken into consideration. Such differences can be detected by a test trial in which all chambers are thermobarometers. Observed differences may be corrected during calculation, or by changing the volume of the chamber. This latter step may be done empirically by adding paraffin to the chamber. It might be noted that the volumetric change resulting from the presence of a 20 mg. fly in a 2 ml. chamber is only 1%.

SUMMARY

An apparatus for measuring the oxygen consumption of insects (house fly size) is described. The protocol of a trial is included.

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A STUDY OF THE MORPHOLOGY OF THE IMMATURE STAGES OF AEDES TRIVITTATUS (COQUILLETT) (Diptera: Culicidae)[1]

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INTRODUCTION

The breeding habits of the various species of mosquitoes and the character and amount of precipitation are so variable that it often happens that all larvae collected at a particular time are immature, or that immature larvae of one or more species are associated with mature larvae or all developmental stages of other species; so the values of being able to recognize the immature larvae at the time of collection are obvious.

Since (1917), when Howard, Dyar and Knab first described the fourth stage larva of numerous species including that of *Aedes trivittatus*, subsequent authors followed in almost the same line, until Dodge (1945), realizing the very little attention given to the early larval instars, studied and made keys to the first stage larvae of 59 North American species of mosquitoes, including a brief description of *Aedes trivittatus*. He concluded that specific and generic differences are as well marked in the first instar as in the fourth, and the same characters used in determining fourth stage larvae may apply to the first instar. Abdel-Malek and Goulding (1948) put emphasis on the value of using the head capsule widths, the length of the air siphons, or both these characteristics in combination, as criteria for determination of the larval instars of four species of mosquitoes, namely: *Aedes aegypti*, *Aedes trivittatus*, *Culex apicalis* and *Anopheles quadrimaculatus*.

Aedes trivittatus (Coq.) breeds in open sites where temporary pools are apt to be formed by rain or flood. *Aedes vexans* and *Psorophora ferox* are almost always associated with *Aedes trivittatus* wherever the latter is found in its breeding sites. This paper deals with the morphology of the immature stages of this species.

MORPHOLOGY OF THE IMMATURE STAGES

Egg Stage

(Plate I, fig. 1)

On an average the egg is 0.574 mm. long by 0.178 mm. wide. The egg is fusiform in shape. The whole of the external surface of the egg is sculptured into large and small lens-shaped bosses, which form a polygonal pattern. The ventral side of the egg is a little flatter than the dorsal side. The color is white when laid and changes to jet black within a few hours.

[1]Contribution from the Department of Zoology and Entomology.

First Stage Larva

(Plate I)

The length of the larva in this stage varies from 2.4 to 4.3 mm. with an average length of 3.7 mm. The average head width and length of the air siphon are 0.312 mm. and 0.286 mm. respectively.

The head is broader than long and is formed as in the case of the rest of the larval instars of four sclerotized plates. These are (a) the frontoclypeus, occupying the greater part of the dorsal surface of the head capsule; (b) a pair of epicranial plates forming the lateral and most of the ventral surface of the capsule; (c) the gula, a more or less small inverted V-shaped ventral sclerite extending from the base of the labium to the occipital foramen and is defined laterally by the gular sutures, from which arise a pair of gular apodemes.

Anteriorly, the fronto-clypeus has a narrow forward extension, the preclypeus, carrying the labrum.

On both sides of the head, there is a pair of eyes situated mediolaterally on the epicranial plates. Each eye is in the form of a small, more or less oval, pinkish area with a number of dark spots.

The antennae arise from the epicranial plates near the right and left extremities of the epicranial suture. Each antenna is less than half as long as the head and is slender and slightly tapering to the apex. The antennal shaft is studded with numerous forwardly pointing spinules arranged in a more or less oblique row. Projecting from the posterior one-third of the dorsal side of the antenna is the antennal hair which is trifid and with the individual branches reaching more or less the anterior fourth of the antenna. The anterior extremity of the antenna (Fig. 3) is truncate and carries four long slender spines and one short stout spine less than one-fourth of the length of the long spines.

The head carries a number of symmetrically arranged paired simple hairs which are in approximately the same positions as those in the fourth stage except that the upper head hairs (UHH) are not in line with the lower head hairs (LHH), but are more outwardly placed. In addition to the above hairs, there is a pair of long, stout, and more or less spine-like hairs on the preclypeus known as the preclypeal hairs (PRCH). On both sides of the dorsomeson and more or less in a horizontal line with the lower head hairs is a pair of moderately short hairs known as the posterior clypeal hairs (PTCH). A pair of single barbed long hairs known as the ante-antennal hairs (AAH) are situated on the fronto-clypeus near the insertion of the antennae.

On both sides of the epicranial suture between the eyes and the egg-breaker, there are two pairs of hairs, the sutural hairs (SH) and the trans-sutural hairs (TSH); the former are situated anterior to the latter. Centrally located in each eye is a simple long hair known as the supra-orbital hair (SOH).

On the frontoclypeus, midway between the eyes, is a fairly large oval depression in which is situated the egg-breaker (EGB) (Fig. 2) which is a brownish club-shaped plate with a median very strongly chitinized dark cone.

The upper lateral abdominal hairs are double on the first three segments and single on the remainder. The lateral comb of the eighth

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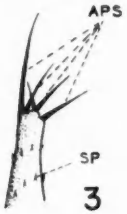

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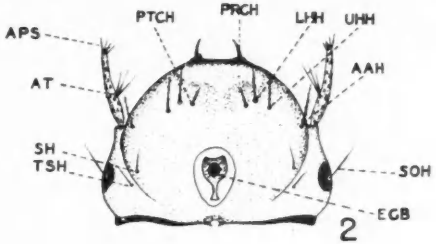

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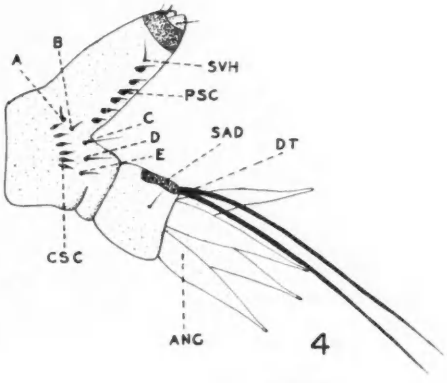

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PLATE I

Aedes trivittatus (Coquillett), egg and first stage larva. Fig. 1. Egg. Fig. 2. Head, dorsal aspect. Fig. 3. Extremity of antenna. Fig. 4. Eighth and ninth abdominal segments. Fig. 5. Pecten scale. Fig. 6. Lateral comb scale.

segment is formed of five to six fairly large scales in an even row. Each individual scale (Fig. 6) is elongate thorn-shaped with a fairly long spine at the apex, about one–third the length of the body of the scale. Along the sides of the scale there are delicate fairly long hairs. Posterior to each comb along the distal margin of the eighth segment there is a group of five simple and long hairs, called the pentad hairs by Dodge 1945. These hairs were designated by Greek symbols by Marshall (1938), but the writer prefers the Arabic designations adopted by Hearle (1929) and Dodge (1945), thus labeling them A, B, C, D, and E (Fig. 4).

The eighth abdominal segment carries dorsally the breathing tube or air siphon. It is cylindrical in shape with a slight constriction near the apex. It is about three times as long as wide with the apical one–sixth well sclerotized and brownish in color. The siphon carries a pair of ventrolateral rows of detached flattened scales, each row being known as a pecten. The pecten (Fig. 4) is formed of six to seven widely separated scales (PSC) reaching beyond the middle of the siphon length. Each individual scale (Fig. 5) is more or less triangular in outline and produced at one side into six to seven spines, the distal one being the longest and the remainder progressively shorter towards the base of the scale.

The saddle of the ninth segment is narrow, well sclerotized, and more or less oval in outline. It covers the dorsal posterior half of the segment and reaches only a very short way down the sides of the ninth segment. Subdorsally on each side of the posterior third of the ninth segment there is a long delicate hair.

On the posterior dorsal end of the ninth segment there are four long, stout hairs forming the dorsal tuft (DT). There is no ventral tuft in this stage.

The four anal gills (ANG) are long and pointed with a length approximately four times that of the saddle.

The general color of the larva in this stage is brownish-white with the head capsule and other sclerotized parts brownish.

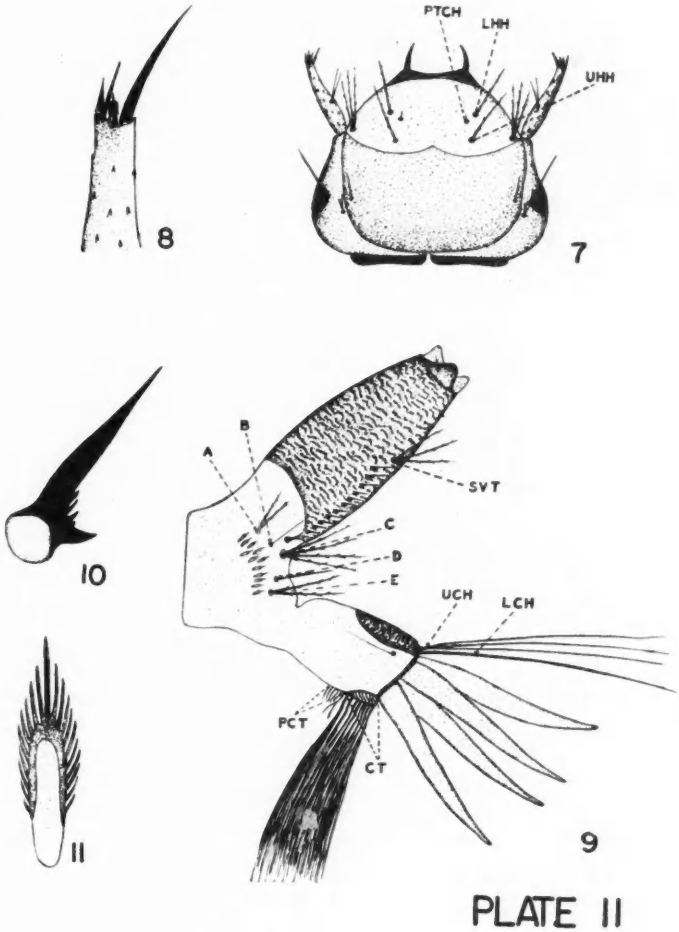
Second Stage Larva

(Plate II)

The length of the larva in this stage varies from 2.43 to 4.14 mm. with an average length of 3.1 mm. The average width of the head capsule and length of the air siphon are 0.550 mm. and 0.479 mm. respectively.

The head in this stage is broader posteriorly than in the first instar. The eyes resemble those of the first instar except being somewhat bigger. The antennae are broadened towards the base and are slightly curved inwards. The anterior extremity of the antenna carries one long slender appendage and four shorter stout ones, one of which is truncate. The antennal tuft (Fig. 7) is usually bifid and arises from nearly the posterior third of the antenna. The hairs of the antennal tuft do not reach the anterior end of the antenna.

The head capsule hairs are in the same positions as in the first instar except that the upper head hairs are situated slightly inwards to the lower head pair. Both the upper and lower head hairs are sparsely barbed. The ante-antennal hair is formed of three barbed branches and reach nearly the antennal hair tuft.



Aedes trivittatus (Coquillett), second stage larva. Fig. 7. Head, dorsal aspect. Fig. 8. Extremity of antenna. Fig. 9. Eighth and ninth abdominal segments. Fig. 10. Pecten scale. Fig. 11. Lateral comb scale.

All the hairs, other than the upper, lower and ante-antennal hairs, are much reduced in length. The transsutural hair has two to three branches and the supraorbital hair is simple (Fig. 7).

The egg breaker is lost in this stage. The upper lateral abdominal hairs are double on the first abdominal segment only and single on the remainder.

The lateral comb of the eighth segment is formed of eight to twelve scales arranged in a triangular patch of two irregular rows. Each individual scale (Fig. 11) has a stout apical spine about half as long as the body of the scale. On both sides, the scale is fringed with delicate hairs. The pentad hairs (Fig. 9) situated posterior to the lateral comb are in the same positions as those of the first instar, but are different in being longer and some of them are branched. The A hair has two barbed branches, the B hair is simple, the C hair with three to four barbed branches, the D hair is simple, and the E hair has two barbed branches.

The air siphon is conical in shape, with the broadest portion near the basal one-third. The siphon is about two times long as wide and with the apical four-fifths well sclerotized and light brownish in color. The pecten is formed of eight to twelve uniformly spaced scales reaching a little beyond the middle of the siphon. Each pecten scale (Fig. 10) is formed of a long apical tooth or rarely sometimes two, followed by from five to six shorter teeth. Each pecten is followed by a three branched hair tuft, the subventral hair tuft (SVT) the branches of which are barbed.

The saddle covers nearly two-thirds of the dorsal surface of the ninth segment and reaches about one-fifth down the sides of the segment. Both the saddle and the siphon are well sclerotized and with many minute spinules over their surfaces arranged in alternate transverse rows. Laterally, on both sides of the posterior one-third of the ninth segment, there is a pair of long delicate single hairs. The dorsal brush arises from the dorsoapical angle of the anal segment and is composed of a pair of upper caudal hairs (UCH) each being three-branched; and a pair of long and single lower caudal hairs (LCH). The ventroapical margin of the ninth segment has a ventral brush formed of two portions: the cratal tuft (CT) posteriorly, formed of eight branched hairs arising from the barred area, and a precratal tuft (PCT) arising anterior to the barred area and formed of seven hairs all of which are simple except the one close to the cratal tuft being bifid. The precratal tuft extends from the proximal end of the cratal tuft to nearly the middle of the ninth segment.

The anal gills are four in number, long tapering and about three times the length of the saddle.

The color of the larva in this stage is brownish white, but darker than the first instar and with two brownish ribbons extending on both sides of the dorsomeson from the posterior half of the thorax to the base of the air siphon.

Third Stage Larva

(Plate III)

The length of the larva in this stage varies from 3.33 to 5.4 mm. with an average length of 4.59 mm. The average width of the head capsule and length of the air siphon are 0.827 mm. and 0.667 mm. respectively.

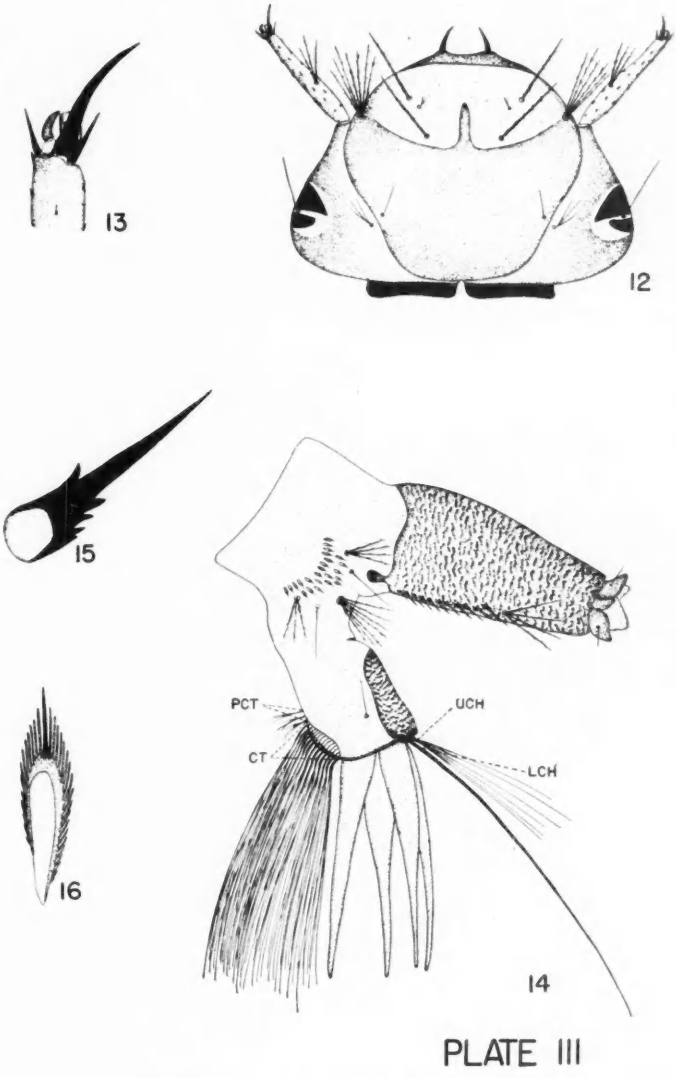


PLATE III

Aedes trivittatus (Coquillett), third stage larva. Fig. 12. Head, dorsal aspect. Fig. 13. Extremity of antenna. Fig. 14. Eighth and ninth abdominal segments. Fig. 15. Pecten scale. Fig. 16. Lateral comb scale.

The head is broader in this stage than in the second instar. The eyes are in the form of a pair of dark patches situated mediolaterally on each side of the head capsule. The additional eye on each side is in the form of a crescent-shaped dark patch of a larger size than the patch originally present in the first and second instars and is situated in front of the latter patch. This anterior patch was considered by Howard, Dyar and Knab (1912) and Marshall (1938) to represent the slowly developing compound eyes of the future adult, showing through the larval skin. The antennae are more or less cylindrical, being only slightly broadened toward their middle length. Apically, each antenna carries five appendages (Fig. 13), a long spine, two short delicate spines, one short stout spine, and a short broad cylindrical appendage. From nearly the middle of the spinulated shaft, arises the antennal tuft (Fig. 12) formed of three hairs not reaching the anterior end of the antenna.

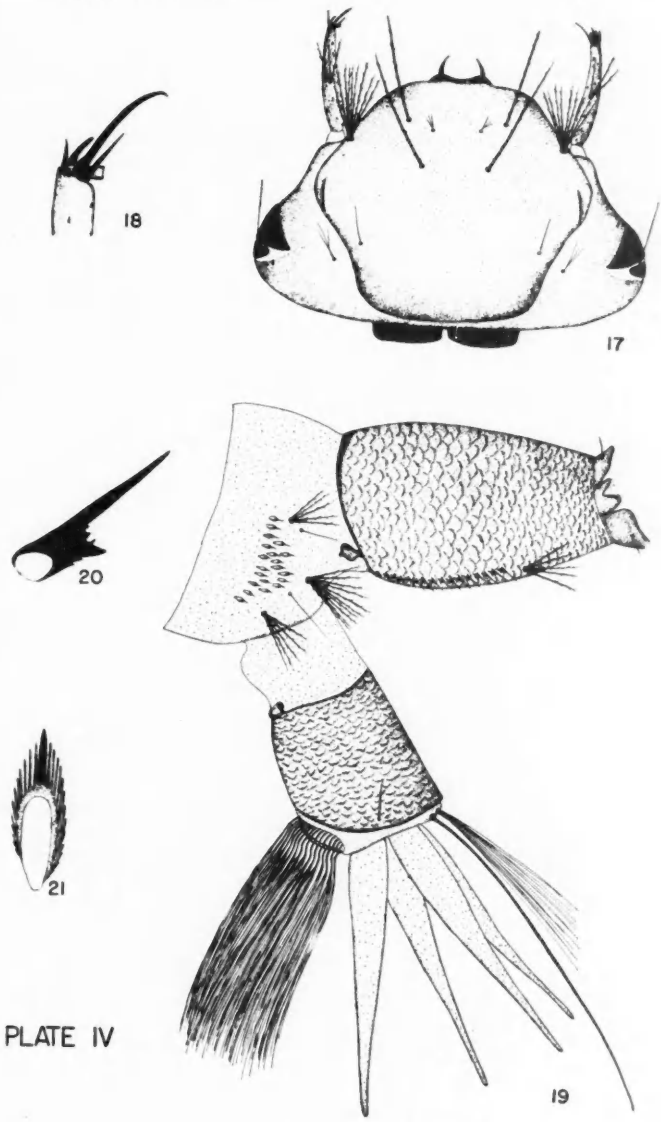
The head hairs (Fig. 12) are in the same positions as in the second instar. The lower and upper head hairs are single and sparsely barbed, the ante-antennal tuft with five to seven barbed hairs; the post clypeal hair short, delicate, and three branched; the sutural hair single; and the transsutural with two to four delicate branches. The supraorbital hair is simple, long, and situated on the upper inner angle of the posterior eye patch.

The upper lateral abdominal hairs are double on the first two abdominal segments and single on the remainder. The lateral comb of the eighth segment is in the form of a large triangular patch of from 19 to 28 scales with an average of 23 scales arranged in three irregular rows. The scales are fairly large, each has a stout apical spine about half as long as the body of the scale. Each scale (Fig. 16) is fringed on both sides with delicate long spines diminishing gradually in length towards the base of the scale. The pentad hairs (Fig. 14) on the posterior margin of the eighth segment vary in branching from those of the second instar. The A hair tuft is three- to four-branched, the B hair is single, the C hair tuft with six to seven branches, the D hair is single and the E hair tuft is two- to three-branched. The hair branches of the tufts A, C, and E are barbed.

The anal siphon is conical in shape. It is nearly twice as long as wide with the widest portion near its middle. Approximately the apical five-sixths of the siphon is well sclerotized and brown in color. The pecten is formed of 11 to 13 equally spaced scales occupying nearly the basal half of the siphon length. Each pecten is followed by a three- to four-branched long hair tuft, the branches of which are barbed. Each individual pecten scale (Fig. 15) has a long apical spine and a varying number of short teeth which may amount to five teeth.

The saddle on the dorsal side of the ninth abdominal segment reaches in this instar about one-fourth down the sides of the segment.

Over the surface of both the siphon and the saddle, there are numerous well sclerotized spinules arranged in alternate transverse rows. The lateral hair of the ninth segment is in the same position as that of the second instar. Each of the upper caudal hairs of the dorsal brush is six-branched, while the pair of lower caudal hairs are long and single. The cratal tuft (CT) of the ventral brush is formed of thirteen branched



Aedes trivittatus (Coquillett), fourth stage larva. Fig. 17. Head, dorsal aspect. Fig. 18. Extremity of antenna. Fig. 19. Eighth and ninth abdominal segments. Fig. 20. Pecten scale. Fig. 21. Lateral comb scale.

hairs, each arising from the barred area and five-branched. The precratal tuft (PCT) is formed of three to four branched small delicate hairs. The anal gills are four in number, conical, tapering apically and about two times the length of the saddle.

The color of the larva in this stage is brownish white, with two brownish ribbons, extending from the middle of the thorax to the base of the siphon along the dorsomeson, more broader than in the case of the second instar.

Fourth Stage Larva

(Plate IV)

The length of the larva at this stage varies from 5.04 to 6.57 mm. with an average length of 6.1 mm. The average width of the head capsule and length of the anal siphon are 1.10 mm. and 0.81 mm. respectively.

The head in this stage is markedly broader than long with the broadest portion basal to the eyes from which the head capsule slopes regularly to the front end. The eyes, as in the case of the third instar, are in the form of two pairs of dark brown patches, situated mediolaterally on both sides of the head capsule. The anterior patch is crescent shaped, nearly four times the size of the posterior patch which is oval in outline.

The antennae are more or less cylindrical with the anterior half slightly curved inwards. The antennae, as in all the larval instars, are studded with numerous forwardly pointing spines. The antennal tuft is inserted near the middle of the shaft and formed of three barbed hairs not reaching the anterior end of the shaft. The anterior end of the antenna (Fig. 18) is truncate and carries five appendages: one stout and long, two shorter and delicate, one short and stout, and a short cylindrical truncate appendage.

The head hairs are in the same positions as in the second and third instars. The upper and lower head hairs are long, single, and sparsely barbed. The ante-antennal hair tuft has eight to nine barbed hairs. The postclypeal hair is short, delicate, and three-branched. The sutural hair is single, the transsutural with three branches. The supraorbital hair is simple, long, and situated on the upper inner angle of the posterior eye patch.

The upper lateral abdominal hairs are double on the first two abdominal segments and single on the rest. The lateral comb of the eighth abdominal segment is in a triangular patch formed of 19 to 28 scales with an average of 22 scales arranged in three irregular rows. Each individual scale (Fig. 21) has a broad apical spine nearly as long as the body of the scale which is fringed on both sides with long delicate subapical spinules. The pentad hairs vary in branching from those of the third instar: The A hair is four- to six-branched, the B hair is single, the C hair with 8 to 13 branches, the D hair is single, and the E hair is four- to six-branched. All the pentad hairs except B and D are barbed.

The anal siphon (Fig. 19) is conical in shape, about twice as long as wide with the widest portion near its middle length. The anal siphon is well sclerotized and light brown in color.

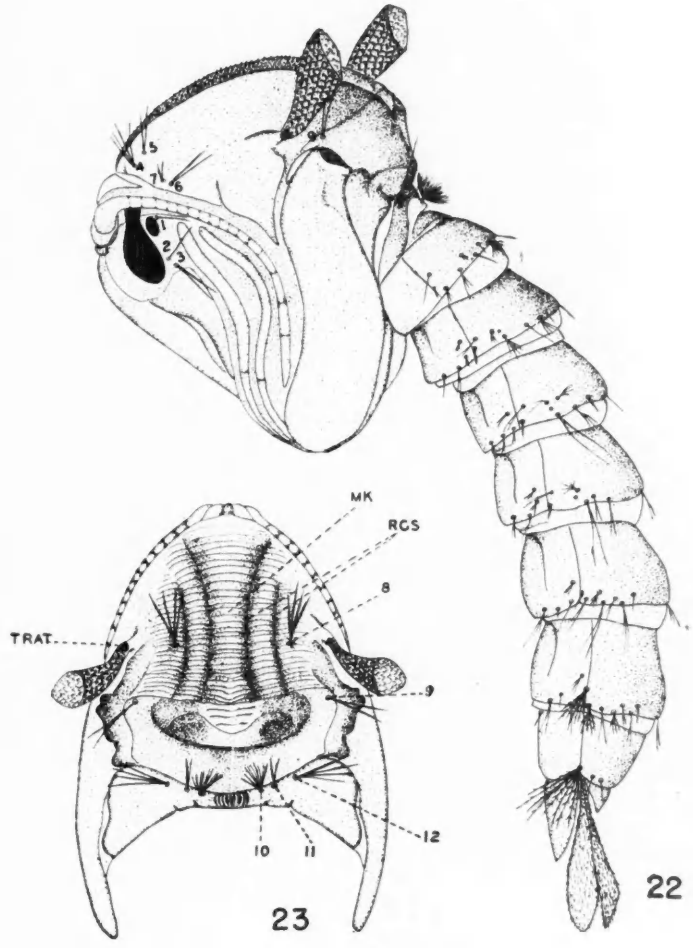


PLATE V

Aedes trivittatus (Coquillett), pupa. Fig. 22. Lateral aspect. Fig. 23. Cephalothorax, dorsal aspect.

TABLE I

SUMMARY OF THE NUMERICAL VALUES OBSERVED IN *Aedes trivittatus* (Coq.) IN THE FOUR LARVAL INSTARS

INSTAR	NUMBER OF LARVAE EXAMINED	LENGTH OF LARVA			WIDTH OF HEAD CAPSULE			LENGTH OF ANAL SIPHON			NUMBER OF COMB SCALES			NUMBER OF PECTEN SCALES		
		Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.
1st	30	2.16	1.21	1.85	0.360	0.225	0.312	0.36	0.225	0.286	6	5	5.76	6	5	5.63
2nd	35	4.14	2.43	3.10	0.63	0.45	0.55	0.54	0.45	0.479	12	8	11.45	11	8	9.68
3rd	23	5.4	3.33	4.59	0.90	0.72	0.827	0.81	0.58	0.667	28	19	22.48	13	10	11.96
4th	10	6.57	5.04	6.10	1.17	1.08	1.107	0.90	0.81	0.814	28	19	21.9	17	15	15.8

The pecten is formed of 15 to 17 equally spaced scales occupying nearly the basal half of the anal siphon. Each pecten is followed by a tuft of four to five hairs known as the subventral tuft. Each individual pecten scale (Fig. 20) has a long apical spine and from five to eight short basal ventral teeth. The ninth abdominal segment is longer than wide with the saddle surrounding completely its posterior three-fifths. The skin of the body is smooth without spinules except on both the saddle and siphon where there are numerous spinules arranged in alternate transverse rows.

The lateral hair on both sides of the ninth abdominal segment is single and delicate and in the same position as that of the third instar.

The dorsal brush is formed of a pair of long unbranched caudal hairs and a pair of shorter multiple-branched upper caudal hairs. The ventral brush is formed of 16 multiple-branched hairs arising from the barred area and forming the cratal tuft. The precratal tuft is absent in this stage.

The anal gills are four in number, long, tapering, and about two times the length of the saddle.

The color of the larva is similar to that of the third instar.

A summary of all the numerical values observed in all the four larval instars of *Aedes trivittatus* is represented in Table I.

Pupa

(Plate V)

The pupa, as usual in all mosquitoes, is comma-shaped with the head of the comma representing the cephalothorax and the tail the pupal abdomen. The most noticeable feature of the cephalothorax is the compound eye of the future adult which shows conspicuously through the integument. The eye is accompanied by the small oval pupal eye. Among other visible contents of the cephalothorax, are a number of flexible, chitinous sheaths, within which the mouth parts, antennae, legs, wings and other appendages of the future adult are located. The respiratory trumpets are narrow at their bases and are distally divergent. They are dark brown in color with a length of about 0.67 mm. on the average. According to Macfie and Ingram (1920) the respiratory trumpet can be regarded as divisible into a closed tubular portion called the meatus, and an open portion called the pinna. In *Aedes trivittatus* there is a small definite tracheoid area at the base of the meatus. The ratio of the length of the meatus to the total length of the respiratory trumpet is about 1 : 1.43. The whole surface of each trumpet is covered with a fine network carrying a great number of short curved spinules.

The dorsal surface of the cephalothorax (Fig. 23) bears two pairs of prominent ridges (RGS) on both sides of a strong median very noticeable keel; this median keel (MK), along which the skin splits when the imago emerges, is provided with a variable number of strong transverse ribs extending all the way through the ridges.

The arrangement of the cephalothoracic setae appears to be similar to those in *Aedes aegypti* (Macfie 1919). There are twelve pairs of setae in all; three on the head shield, called the postocular (1–3); four near the front margin of the thorax, called the anterothoracic (4–7); one on the dorsal surface of the thorax near the trumpets, called the dorsal

seta (8); one supraalar (9) at the base of the wing case, and three posterior-thoracic (10–12) on the metanotal plate.

The postocular setae. These are composed of: (a) ***the upper postocular seta*** (1), long, delicate, and situated posterior to the upper posterior angle of the eye; (b) ***the median postocular seta*** (2), delicate, small, and situated behind the eye near its lower margin; (c) ***the lower postocular seta*** (3), of moderate length, delicate, and situated posterior to the median seta and a little outer to it. Both the median and lower post ocular setae may be single or double.

The anterothoracic setae. These are composed of: (a) ***the lower anterior seta*** (4), of moderate length, situated a little above the antennae, and divided into four or five branches; (b) ***the upper anterior seta*** (5), delicate, of moderate length, situated above and slightly posterior to the lower anterior seta, and either two or three-branched; (c) ***the lower posterior seta*** (6), stouter and longer than the preceding, situated just close to the upper margin of the antenna above the eye, and two-branched; (d) ***the upper posterior seta*** (7), stout and short, situated close to and a little anterior to the lower posterior seta; it may be bifid.

The dorsal seta (8) is a delicate, rather long seta situated on the thorax a little posterior and internal to the respiratory trumpets. It may be four or five-branched.

The supraalar seta (9) is a moderately long, delicate seta situated on the thorax above the roots of the wing. It may be two or three-branched.

The posterior thoracic setae. These are moderately well developed and formed of three setae: (a) ***the internal seta*** (10), of moderate size and eight or nine-branched; (b) ***the median seta*** (11), stouter and longer than the internal seta and two-branched; (c) ***the external seta*** (12), of moderate length, stout, and may be four-branched.

Pupal Abdomen

(Plate VI)

The abdomen of the pupa is composed of nine segments, the terminal of which is much smaller than any of the other segments. The terminal segment carries a pair of more or less pyriform large paddles (PD). The length of the paddle is about 1.078 mm. and the ratio of its length to the greatest breadth is about 1.5 to 1. The midrib is moderately developed, highly sclerotized and does not reach the distal end of the paddle. The paddles are fringed by minute denticles which also cover their whole surfaces. The terminal seta is situated a bit outside an imaginary line from the midrib to the distal end of the paddle. The terminal seta is about one–sixth the length of the paddle (i.e. about 0.182 mm.) and is single, not branched.

The first eight segments of the pupal abdomen carry, both dorsally, and some of them ventrally, various paired hairs or setae.

The Dorsal Abdominal Setae

(Fig. 24)

On each abdominal segment except the last, there are normally eight or nine dorsal setae on each side. The terminology of the setae used in this description are those adopted by Baisas (1938) in his description of the chaetotaxy of the culicine pupal abdomen. Baisas has adopted

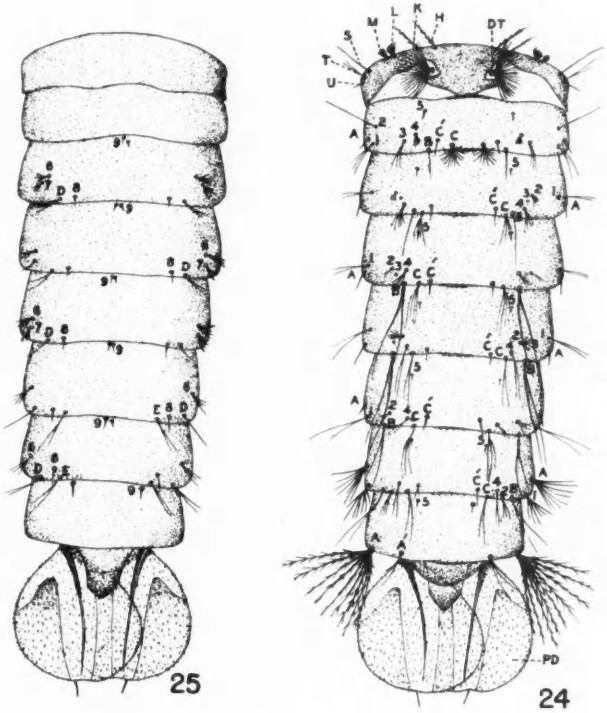


PLATE VI

Aedes trivittatus (Coquillett), pupal abdomen. Fig. 24. Dorsal abdominal setae. Fig. 25. Ventral abdominal setae.

with some modification, the system proposed by Macfie (1919) and developed by Senevet (1936).

The seta on segments II to VII can be homologized without great difficulty and are designated A, B, C, C', 1, 2, 3, 4, and 5. Seta A is very small on all the segments except those on segments VII and VIII where they become large and tuft-like and a bit removed from the posterior corner of the segment. It is ventrolateral in position rather than dorsal. Setae B and C are the largest setae on the posterior margin of the segment.

Seta C' varies in position with respect to C on the different segments. In general it is well removed from the posterior margin and is internal to C in all the segments except the second, where it is external to C.

Seta 1 is the next largest after B and C. It is situated close to the lateral margin and not far from the posterior margin of each segment.

Seta 2, 3, and 4 are small setae lying somewhat anterior to B and C. On segments three to five seta 3 is represented by a small socket without any seta, while on segments six to eight it is absent.

Seta 5 is minute and placed near the anterior border of the segment.

On the first abdominal segment, the setae are also eight in number on each side, but their arrangement is entirely different and they were given a different terminology by Baisas (1938). The most conspicuous is a large tuft near the middle of the segment, which usually has been spoken of as, the dentritic tuft or float-hair as applied by Edwards (1941). It is regarded as being homologous to seta C of the succeeding segments. The remaining setae of the first abdominal segment are four near the anterior border designated H, K, L, and M, and three on the lateral border designated S, T, and U.

On the eighth segment there are only three dorsal setae on each side, designated by Baisas, as A, A' and 5 where A is in the form of a tuft on the posterior corner of the segment, A' is on the posterior margin and moderately long and delicate, and 5 is near the base of the segment.

The ninth segment is without setae.

Details regarding the characteristics and sub-divisions of the dorsal abdominal setae are furnished in the following table.

Segment	*Seta*	*Description of Seta*
I	Dentritic tuft	—Large, well developed, with 16 to 17 strong primary branches, with all the hairs barbed.
	H	Moderately long, stout, barbed seta, situated immediately anterior to the dentritic tuft and directed forwards.
	K	Long, stout, barbed seta, situated near seta H, but a little external and posterior to the latter. It is also directed forwards and may be single or terminally bifid.
	L	A small tuft of about eight hairs, situated nearly in a transverse line with seta H, about halfway between the latter and the lateral margin of the segment. It is directed forwards and outwards.
	M	A small tuft of about six hairs situated close to seta L but slightly anterior and external to the latter. It is directed forwards and outwards.
	S	Very long, strong, barbed seta, situated on the lateral anterior margin of the segment.
	T	Rather long seta, but not as long as seta S. It has two to three branches and is situated close to and external to seta S. It is directed outwards and forwards.

Segment	*Seta*	*Description of Seta*
	U	Small, delicate seta, situated on the border of the segment, external to seta T. Its end may be divided into two branches.
II	A	Small, rather stout.
	1	Rather long, delicate, three-branched, and situated posterior to A.
	2	Long, stout, seta, situated internal and anterior to A.
	3	Rather long, delicate, three-branched seta, situated midway between one and four.
	4	A small tuft of six to eight hairs situated outer and anterior to B.
	B	Rather long, stout, single seta near the posterior border of the segment.
	C'	Stout, single seta, equal in length to B, and situated slightly anterior and internal to the latter.
	C	Rather long tuft of 18 to 20 hairs situated near the posterior border at the middle of the segment.
	5	Minute single seta.
III	A	Small, rather stout, situated latero-ventrally.
	1	Rather long, delicate, two-branched, and situated latero-dorsally, somewhat anterior and internal to the insertion of A.
	2	A small tuft of four to five hairs.
	3	Represented by a small socket without a seta and situated more or less posterior and internal to 2.
	4	Moderately long, delicate, four- to five-branched seta, situated posterior to and inner to seta 3.
	B	Very long, stout, seta, reaching the posterior end of Segment IV.
	C	Rather long, delicate, four- to five-branched seta.
	C'	Small, stout seta situated internal and anterior to C.
	5	Minute.
IV	A	Small, rather stout.
	1	Rather long, delicate, two-branched.
	2	Small, delicate, one- to two-branched.
	3	Represented by a small socket without a seta and is situated posterior and internal to 2.
	4	Longer than seta 2, delicate, five-branched and situated internal and anterior to both setae 2 and 3.
	5	Very long, stout, two-branched seta, reaching the mid-length of segment VI.
	C	Long, delicate, two- to three-branched, reaching about the posterior third of segment V.
	C'	Small, stout, seta, anterior and internal to C.
	5	Minute.
V	A	Small, rather stout.
	1	Long, delicate, two-branched.
	2	Rather long, delicate, six- to seven-branched, situated anterior and more or less internal to B.
	3	Represented by a socket only, situated anterior to seta B.
	4	Long, delicate, two-branched, situated posterior and internal to seta 3.
	B	Very long, stout, two-branched, reaching beyond the posterior end of the sixth segment.
	C	Long, delicate, two-branched, reaching the posterior one-third of segment VI.
	C'	Small, stout seta, situated anterior and internal to seta C.
	5	Minute.

Segment	*Seta*	*Description of Seta*
VI	A	Small, rather stout.
	1	Long, delicate, two-branched.
	2	Rather long, five-branched tuft, situated anterior and more or less internal to seta B.
	3	Missing.
	4	Long, delicate, two-branched, far removed from seta 2, and situated anterior and more or less outer to seta C.
	B	Very long, stout, two-branched seta, reaching nearly the mid-length of the VII segment.
	C	Long, delicate, three-branched seta, reaching the posterior one-third of the seventh segment.
	C'	Small, stout seta, situated anterior and internal to seta C.
	5	Minute.
VII	A	Rather long tuft of six or seven strong hairs.
	1	Smaller tuft than A, consisting of six or seven strong hairs, situated posterior and inner to the insertion of A.
	2	Rather long, delicate, three-branched, situated internal and posterior to seta B.
	3	Missing.
	4	Rather stout, two-branched seta, situated anterior and internal to seta 2.
	B	Rather stout, long, two-branched seta reaching nearly the posterior one-third of the eighth segment.
	C	Long, delicate, two-branched seta, reaching nearly the posterior end of the eighth segment.
	C'	Small, stout seta, situated anterior and internal to seta C.
	5	Minute.
VIII	A	Well developed tuft with eight or nine strong barbed hairs. It is situated on the posterior corner of the segment.
	A'	Long, delicate, two-branched.
	5	Minute.

Ventral Abdominal Setae

(Fig. 25)

The setae on the ventral aspect of the abdomen are few and relatively inconspicuous. The following setae as given by Baisas (1938) may be recognized on each side of the abdomen on segments three to eight.

(a) ***The mediolateral seta*** (6), a little internal to the lateral border and rather posterior to the middle of the segment.

(b) ***The posterolateral seta*** (7), in a lateral position, internal to the posterior angle of the segment.

(c) ***The inner ventral seta*** (8), situated near the posterior margin of the segment, midway between the middle and the posterior angle of the segment.

(d) ***The outer ventral seta*** (D), situated near the posterior margin of the segment between the inner ventral seta and the posterolateral seta.

(e) ***The anterior ventrocentral seta*** (9), situated at the anterior margin of the segment and very close to the ventromeson.

The first and second abdominal segments possess no ventral setae. Setae D, 6 and 8 are present in segments three to seven; seta 7 in segments three to five; seta E in segments six to seven; and seta 9 is present in segments three to eight. On the eighth abdominal segment setae 9 are not close together as is the case in all the other anterior segments, but are widely separated and lie near the anterior margin of the eighth

segment a little internal to the level of insertion of setae E on the seventh segment.

The ventral abdominal setae are described in the following table.

Segment	*Seta*	*Description of Seta*
III	6	Small delicate tuft of four or five hairs.
	7	Small delicate tuft of five or six hairs.
	D	Rather long, delicate, two-branched hair.
	8	Small, single, delicate hair.
	9	Minute.
IV	6	Small, delicate, three-branched hair.
	7	Small, delicate, two-branched hair, longer than seta 6.
	D	Long, delicate, two-branched hair.
	8	Small, single, delicate hair.
	9	Minute.
V	6	Small delicate tuft of four hairs.
	7	Small tuft of five or six hairs, longer than seta 6.
	D	Long delicate single hair.
	8	Small delicate one or two-branched hair.
	9	Minute.
VI	6	Small delicate three-branched hair.
	7	Missing.
	D	Long delicate single hair.
	8	Small single hair situated anterior and outer to E.
	E	Long delicate two-branched hair.
	9	Minute.
VII	6	Small, delicate, two- to three-branched hair.
	7	Missing.
	D	Long, delicate, two-branched hair.
	8	Small single hair situated anterior and outer to E.
	E	Long, delicate, two-branched hair.
	9	Minute.
VIII	9	Minute.

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THE BIOLOGY AND THE IMMATURE STAGES OF THE MOSQUITO, MEGARHINUS SEPTENTRIONALIS DYAR & KNAB[1, 3]

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INTRODUCTION

There is some confusion in the literature regarding the date and place of publication of the original description of *Megarhinus septentrionalis*, and the relationship of this name to *M. herricki* Theobald, the latter now being accepted as a synonym of *M. septentrionalis*. In most publications dealing with the taxonomy of this species, authors have referred to an article by Dyar and Knab, 1907, Jour. N. Y. Ent. Soc. 15: 12, as the place of the original description. In this paper, however, the authors do not describe the species, but indicate that the original description was made in a previous article: Smithsonian Misc. Coll. 48: 249, 1906. The original description is indeed published in this article. Although the date of volume 48 of the Smithsonian Miscellaneous Collections in 1907, the paper in question was actually published in September, 1906. The name *Megarhinus herricki* was given to this same species by Theobald in 1906 (The Entomologist 29: 241), but this publication appeared in November, and this gives a slight priority to the name *M. septentrionalis* D. & K. Although Dyar in his monograph "The Mosquitoes of the Americas" (1928) refers to the article in the Journal of the New York Entomological Society as the place of the original description of the species, future workers should cite the Smithsonian publication to avoid further confusion.

Some workers (Jenkins and Carpenter, 1946) regard *septentrionalis* as a subspecies of *M. rutulis*. According to these workers, a study of larval features of both groups indicates that they are identical. The only known distinction between the adults is a slight difference in coloration of certain tarsal segments in the males. These men have studied series of males and state that even this distinction shows intergradation in areas where the two groups overlap.

Megarhinus septentrionalis is one of the largest mosquitoes in the United States, but the adults do not bite. Observations have confirmed that both males and females of several species of the genus feed upon flower nectar and possibly other plant juices (Knab, 1907, 1911). The larvae are carnivorous, and they have been seen to feed upon the larvae of other mosquitoes. The eggs are usually deposited

[1]Supported by The University of Texas Research Institute.
[2]The writer greatly appreciates the assistance of Mrs. Sarah Martin who made the drawings, and Dr. Robert Matheson and Mr. Curtis W. Sabrosky who aided in determining the place and date of the original description of the mosquito.
[3]Since this paper was submitted for publication, it has been found that the name *Toxorhynchites* Theobald has priority over *Megarhinus* Robineau-Desvoidy.

in tree holes containing water, but larvae have been collected occasionally from water in artificial containers.

This mosquito is now known to occur generally over the eastern and southeastern United States from New Jersey and Northern Florida, west to central Kansas and Texas (Jenkins and Carpenter, 1946). In some parts of its range, it has been reported as passing the winter in the larval stage.

THE PRESENT STUDY

The writer and his associates have been collecting tree hole breeding mosquitoes in central Texas for the past two years. Most intensive work has been done in the vicinity of Austin, but other collections have been made at Palmetto State Park near Luling, and at Round Rock, Stephenville, Bartlett, Marquez and Fredericksburg, Texas.

Eggs and larvae of *M. septentrionalis* in various instars have been obtained. Larvae, either collected from the field or hatched from eggs, were isolated in small staining dishes containing tree hole water, and reared in the laboratory. No attempt was made to control the laboratory temperature, but since most of the work was done in the spring and summer, the laboratory temperature was probably comparable to outside temperature, except that at night the former was probably somewhat higher. Living larvae were studied under a dissecting binocular microscope. Some larvae were mounted on slides, while the skins of those reared to maturity were preserved for study. The larvae were kept constantly supplied with food in the form of tree hole mosquito larvae, and adult and larval *Drosophila* or fruit flies, the latter being kindly furnished by the geneticists of the Department of Zoology.

More than 30 early larval instars were studied in this work, all collected near Austin, Texas. Of this number, 10 were reared successfully from the egg stage, while 7 others were reared from young instars collected in the field. The additional specimens either were mounted for study, or died before they emerged as adults. In addition, a large number of fourth stage larvae collected in nature from several localities have been studied and observed in the laboratory. Larger series of early instars collected from distant localities may show some variations from the structures and reactions observed by the writer.

GENERAL BIOLOGY

Megarhinus septentrionalis probably passes the winter as an adult in this area. Numerous collections have been made during the winters of 1946–47 and 1947–48, and although other species of tree hole breeding mosquitoes were frequently found, no larvae of this species have been collected before April.

On April 3, 1947, the writer discovered a large number of eggs of this species in a cavity in a live oak tree (*Quercus virginiana*). While preparations were being made to collect the eggs, a female *Megarhinus* flew to the opening, and disregarding the writer whose head was within a yard of the tree hole, dipped up and down above the water surface. These movements continued for approximately a minute, during which time the insect was humming audibly, the sound being loudest as the mosquito attained a position closest to the water. The insect was

captured as it rested on the tree trunk after it had finished its aerial "dance." It is thought probable that the mosquito was ovipositing during this flight, but since a number of previously deposited eggs were on the water surface, this could not be determined positively. This method of oviposition has been suggested for other species of *Megarhinus* (Howard, Dyar and Knab, 1912; Jenkins and Carpenter, 1946).

As indicated above, the *Megarhinus* larvae were fed on mosquito larvae and larval and adult fruit flies. All the first group of larvae that were obtained from eggs were started on mosquito larvae, but after a week or so, the supply of mosquito larvae could not be maintained and fruit flies were used as substitute food for some of the mosquitoes.

Morgan and Cotton (1908) report that *Megarhinus* larvae do not actively hunt their food, and that they will attack other mosquito larvae only if the other larvae bump into them or come quite close. This method of feeding is apparently generally accepted by most workers, and the mosquitoes used by the writer reacted in this way when mosquito and fruit fly larvae were used. But when adult fruit flies were placed on the water surface, a very interesting reaction was observed in the *Megarhinus* larvae under some conditions. Fruit flies placed on the surface usually start struggling to escape. These movements caused no reactions from the mosquito larvae if they were beneath the surface. But when the siphons of the larvae were in contact with the surface film, the insects were almost immediately attracted by the struggles of the flies. If the heads of the larvae were directed toward the flies, they would start swimming at once toward the insects. Otherwise, the mosquito larva would swing its body about toward the disturbance before swimming to the fly. Once a larva was under a struggling fly, it would seize a portion of the fly's body, and with a quick flip, attempt to drag it beneath the surface. Sometimes the mosquito would be successful at the first trial, but in the case of larger flies, the film of air about the body made it necessary for the larva to try several times before it was successful. Several times a mosquito larva struck at a fruit fly on the surface, but did not succeed in seizing it. The striking movement carried the mosquito beneath the water surface. In such instances, the mosquito frequently returned to the surface and struck again even though the siphon was at that time out of contact with the surface film. In some cases the complete fly was eaten, while in others, a few parts such as the wings were rejected. Light was not of any apparent significance in these reactions, since larvae in darkness caught flies as readily as did those exposed to the light of the laboratory.

Tests showed that a struggling fruit fly would attract the *Megarhinus* larvae as far away as 1½ inches, but small adults at least did not cause any reactions at a greater distance than this. Occasionally the mosquito larvae were not attracted to the adult fruit flies, even though their siphons were in contact with the surface film. However, tests at later dates did cause reactions in most individuals.

All reared larvae progressed rapidly to the fourth instar whether fed mosquito larvae, fruit flies or both. After the fourth instar was

attained, however, the developmental rate differed greatly depending upon the type of food that was used. All specimens reared from the egg stage preferred adult fruit flies to mosquito larvae in the fourth instar, and they would frequently eat fruit flies when mosquito larvae were totally disregarded. Larvae that were reared entirely on *Drosophila* (larvae during the early instars and adults later), or those that were fed adult fruit flies during the last instars, passed from egg to adult in from 25 to 35 days. No larvae fed entirely on mosquito larvae were reared to adults. They attained the fourth instar and remained in this stage as long as several months, or until fed adult fruit flies.

It seems probable that the length of the fourth larval instar was dependent, in part at least, upon the amount of food consumed by the

TABLE I

LARVAE FED ADULT DROSOPHILA IN LATE INSTARS

Larva	Egg Hatched	Became 4th Instar	Pupated	Emerged
1	April 4	April 18	April 28	May 3
2	April 4	April 17	May 4	May 8
3	April 4	April 20	May 4	May 8
4	April 14	April 26	May 5	May 9
5	April 14	April 30	May 6	May 11

TABLE II

LARVAE REARED TO FOURTH INSTAR ON MOSQUITO LARVAE

Larva	Egg Hatched	Became 4th Instar	Adult Fruit Flies Fed	Pupated	Emerged
1	April 4	April 15	May 31	June 5	June 9
2	April 4	April 15	June 19	June 25	June 29
3	April 4	April 15	Aug. 8	Aug. 28	Sept. 2

larvae. Although the insects were kept continuously supplied with mosquito larvae, they would frequently disregard this potential food for two or three days. Several *Megarhinus* larvae averaged eating approximately one mosquito larva every two days over a period of several weeks, while others, fed on adult *Drosophila*, often ate several flies daily. Fruit flies reared on specially prepared food may, of course, contain elements not found in mosquito larvae, and these substances may have influenced the appetites and speeded the metamorphosis of the *Megarhinus* larvae.

Several larvae were reared to fourth instar using mosquito larvae only, and then were taken at intervals and fed adult fruit flies. These larvae later pupated and emerged as adults. Accurate records were kept on several specimens using both types of food. Those in Table I were fed adult *Drosophila* during the late instars, while those in Table II

were kept supplied with mosquito larvae only until the date indicated in the table.

These observations indicate that in nature adult insects that disturb the surface film may form a larger percentage of the diet of ***Megarhinus*** larvae than formerly thought. Fourth stage larvae collected in the field and exposed to adult fruit flies in the laboratory reacted just as vigorously as did laboratory reared specimens. It is doubtful, however, that these larvae are of much importance in destroying freshly emerged adult mosquitoes, or those that happen to alight on the surface. All such adult mosquitoes that have been observed by the writer have not moved about to any extent, and ***Megarhinus*** larvae have never been seen to attack anything that was not actively moving at the time. Newly emerged adults of ***Orthopodomyia signifera*** and ***Aedes triseriatus*** have been seen resting on a water surface without attracting the attention of ***Megarhinus*** larvae that were in the water.

It is well known that the mouth brushes of ***Megarhinus*** larvae are modified into relatively large hook-like structures, and it has been stated frequently that the larvae use these brushes to seize and hold the prey during feeding. The writer has not determined if this action has actually been observed, or if this is only an assumption based upon the structure of the modified brushes. The writer has frequently watched ***Megarhinus*** larvae under a binocular dissecting microscope seize mosquito larvae and adult fruit flies, and the feeding process has been observed. In all cases the mandibles alone were used, and the employment of the brushes has never been seen. However, it is possible that the proper functioning of the mandibles is dependent in some way upon these brushes. In two cases fourth stage larvae apparently received an injury to the mouth brushes, since the structures were not folded against the sides of the head as usual, but extended laterally at an angle. Both these larvae tried time and again to seize mosquito larvae and fruit flies, but they were never successful and eventually they died.

THE IMMATURE STAGES

The Egg:—The eggs of this species (text fig. 1) have been observed and briefly described by several workers. They are pure white, oval in shape and the surface is studded with small tubercles. It has been suggested that the white color is caused by air bubbles, but this is not the case, since material scraped from the surface remains as a while deposit after it has dried.

The eggs float high on the water surface, and they are very difficult to work with. If one tries to pick up an egg with a pipette, several attempts must usually be made before the worker is successful, since the egg frequently slides along the surface film if disturbed. Once an egg has been caught within a pipette, care must still be exerted in putting it into a container. Several eggs were lost because they bounced from the water surface and out of the staining dish into which they were being placed. The bouncing characteristic of the eggs is probably correlated with the oviposition habits of the adults; that is assuming that the females actually do oviposit as they dip up and down above the water—a habit generally accepted by most workers. In many instances

the female is not directly above the water when she deposits the eggs, but if the eggs were expelled with some force, they could conceivably strike the sides of the tree hole and bounce down into the water. The female observed by the writer that was probably ovipositing, dipped up and down at the outer opening of the cavity, and was never directly over the water which was several inches back from the opening.

Eggs brought into the laboratory hatched within 24 to 48 hours after having been collected. Although the eggs are not immersed in water, some contact with water or at least a high humidity is necessary for their survival since they disintegrate if allowed to dry.

1

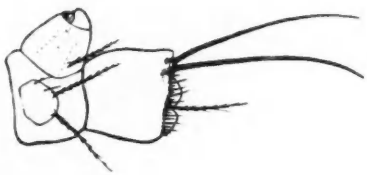

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FIG. 1. Egg of *Megarhinus septentrionalis* D. & K.
FIG. 2. Posterior segments of first stage larva of *Megarhinus septentrionalis* D. & K.

In the discussion of the larval instars to follow, only those structures are emphasized that are of importance in distinguishing the different stages.

First Larval Instar:—The hatching process has not been seen, but several specimens have been observed a short time after hatching. The larvae are at first semi-transparent and white except for the mandibles, eyes, the so-called egg burster near the center of the head and a few splotches of brown scattered over the thorax and abdomen. Within 24 hours, however, the head, siphon and anal segment have become a dark brown color, and sclerotic areas from which groups

of hairs arise have become evident over the thorax and abdomen. Thoracic and abdominal hairs are similar to the condition found in later instars, but the hairs are somewhat longer compared with the width of the body.

Unless disturbed, the larvae have a tendency for a time to remain at the surface. They lie almost parallel with the surface, probably because of the very short siphon, and they may easily be mistaken for *Anopheles* upon casual examination. When moving from one place to another the larvae have a tendency to "crawl" along the surface film using the siphon to push themselves forward, sometimes accompanied by slight wiggling movements.

Larvae only a few hours old feed readily, and they are not adverse to attacking larvae several times their own bulk. On several occasions, second and third stage larvae of *Aedes triseriatus* have been seized by recently hatched *Megarhinus* larvae and overcome, despite the furious struggles of the victim. In most cases, larvae of this size were only partially eaten. Cannibalism was observed once or twice before specimens were segregated, but they did not seem to be as much attracted to their fellows as to other species of larvae. Several times, the larvae were seen to bump into each other with no reaction from either party, while on one occasion three *Megarhinus* larvae fed peacefully upon a larva of *A. triseriatus*.

The most striking differences between the first and succeeding instars occur in the posterior abdominal segments (text fig. 2). No ventral brush is present, and the dorsal brush consists of four hairs, two on each side. The siphonal hair or subventral tuft is a single barbed hair. The siphon is much shorter, compared with the ninth or anal segment, than in other instars.

Second Larval Instar:—A ventral brush appears in the second instar (Plate I, fig. 1). The dorsal brush consists of two tufts of hairs on each side, the upper of which usually has three or four branches, while the lower has two. The siphonal hair is still a single barbed hair.

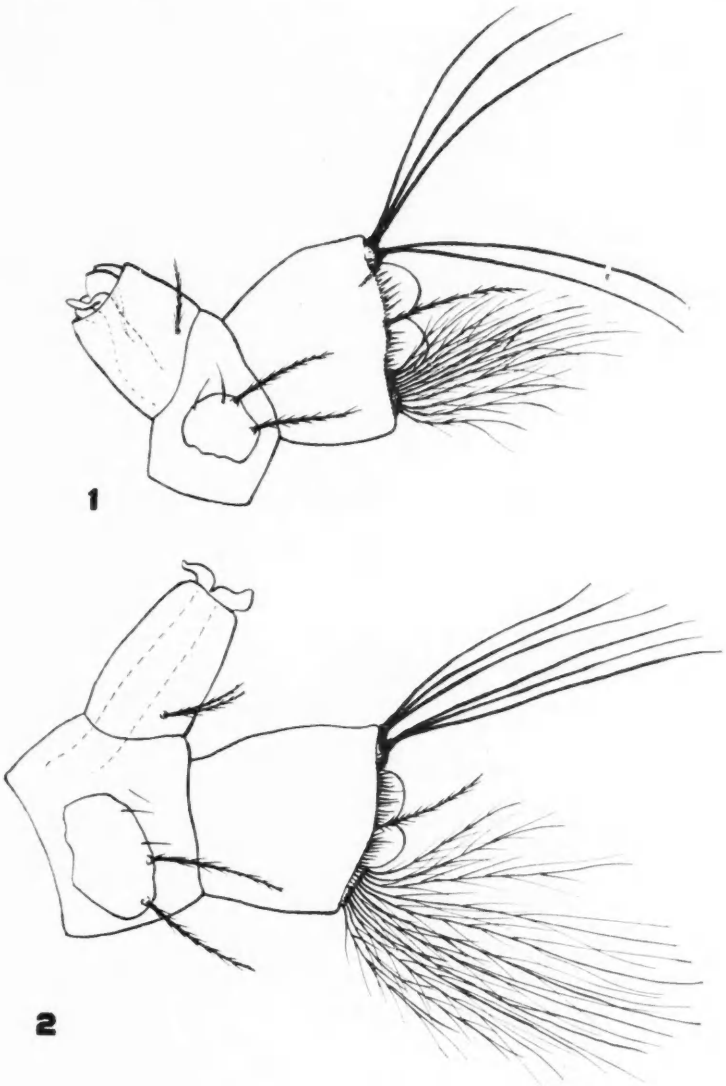
Third Larval Instar:—The upper tuft of the dorsal brush in the third instar may have from three to five branches on each side, while the lower tuft has three (Plate I, fig. 2). The siphonal hair has now become a tuft with two to three branches. The ventral brush is similar to that of the second instar.

Fourth Larval Instar:—The upper tuft of the dorsal brush has from five to eight branches on each side (text fig. 3). The lower tuft usually has four branches, but may occasionally have five. The siphonal hair is now a multiple tuft with many branches, while the ventral brush is similar to that of the second and third instars.

Fourth stage larvae differ from the other instars in the structure of the mouth brushes. In all instars except the last, each mouth brush has several small teeth on the end, but no teeth occur in the fourth although each brush has a rather sharp curved point.

It should be noted that each instar can usually be identified by the number of branches in the lower tuft of the dorsal brush. As a rule, there is a single branch on each side in the first instar, two branches in the second, three in the third and four or five branches in the fourth.

Neither ecdysis nor pupation have ever been observed, but both



Posterior segments of larvae of *Megarhinus septentrionalis* D. & K.
Fig. 1. Second instar. Fig. 2. Third instar.

processes must be quite rapid. On several occasions larvae have been examined at intervals for long periods in an attempt to see actual ecdysis or pupation. In several instances, a specimen has been examined as a normal larva, and less than ten minutes later a subsequent observation showed that ecdysis or pupation had occurred. Fourth stage larvae within a few hours of pupation can be identified. The thorax of the larva becomes semi-transparent along the sides and some of the pupal structures can be seen through the pupal skin.

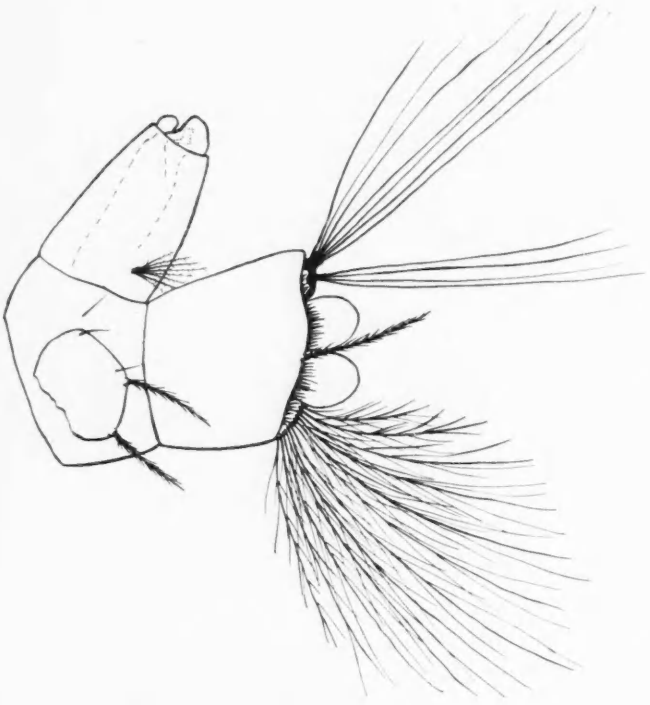


FIG. 3. Posterior segments of fourth stage larva of *Megarhinus septentrionalis* D. & K.

SUMMARY

1. Observations have been made upon specimens of the mosquito, *Megarhinus septentrionalis* D. & K. reared from egg to adult. Possible oviposition of a female is described.

2. Larvae were fed other mosquito larvae, and larval and adult fruit flies. Fourth stage larvae exhibited a decided preference for adult fruit flies, and the use of adult fruit flies was necessary before the larvae would pupate.

3. The modified mouth brushes of *Megarhinus* larvae have previously been assumed to be used for capturing and holding prey. Observations of the feeding process have failed to confirm this, and consequently the previously accepted function of these mouth brushes is questioned.

4. Characteristics of the eggs are described, and distinguishing features of the four larval instars are discussed.

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THE CORIXIDAE OF THE WESTERN HEMISPHERE, by H. B. HUNGERFORD. Univ. Kansas Sci. Bul. 32: 1–827, 112 plates, 19 text figures. 1948.

The identification of the American Corixidae which in the author's words "has been a difficult and discouraging task for many years," should be greatly facilitated by this monograph. In it, Dr. Hungerford has included, under one cover, a comprehensive treatment of the family as it occurs in the Americas, with keys, descriptions, distributional data, information as to the location of types, and some biological information. One color plate, photographs, half-tones, line-drawings, and distributional maps of the individual species, constitute the illustrations. Most of the work is original, although the author has, for the sake of completeness, included keys, descriptions, and plates from Deay's revision of the genus *Tenagobia*, and Sailer's previously unpublished monograph of *Trichocorixa* (pp. 289–407) is included. This treatment has led to certain inconsistencies of style, but the user of the work should not find these troublesome. A new subfamily classification is proposed, with six subfamilies of the world, three of which are new. A new tribal classification is likewise proposed for the Corixinae. In all, 209 species, of which 51 are new, and 12 subspecies, of which 9 are new, are discussed.

Special mention might be given to the series of wash drawings, Plates IV to VIII inclusively, which illustrate the genera and subgenera of the world. These immediately follow the key to the subfamilies, and would have been still more useful if the subfamily and tribal designations of the genera had been included in the legends. The discussion of techniques of study and of preparation of genitalia, the latter particularly well outlined by Dr. Sailer (pp. 300–301), should be very useful. Finally, Dr. Hungerford's discussion of corixid systematics and of generic concepts may be read with profit by any taxonomist.—M. T. J.

FIVE NEW BUPRESTIDAE FROM SOUTH TEXAS (COLEOPTERA)[1]

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The following Buprestidae were collected while the writer was stationed in South Texas with the U. S. Public Health Service. Throughout the preparation of this paper the invaluable guidance given by Mr. W. S. Fisher is gratefully acknowledged. The writer also is indebted for the privilege of studying the extensive collections of Buprestidae in the U. S. National Museum. Dr. J. N. Knull has kindly compared a number of the specimens with types in his collection.

Chrysobothris pubilineata n. sp.

Figs. 1–6

Male.—Form and size of *cupreohumeralis* Van Dyke; head brassy green becoming bronzy black at occiput; pronotum bronzy black; elytra bronzy brown, with a broad area bright red cuperous along the lateral margins, and each elytron with moderately long recumbent whitish pubesence arranged in five narrow but rather distinct lineae; surface beneath bronzy black and almost obscured with white pubescence and efflorescence; legs bronzy black.

Head with front rather flat, somewhat densely hairy, granulose, and coarsely but shallowly and uniformly punctate; antennae bronzy black, gradually narrowed to apex, and barely extending to middle of pronotum when laid along side margin.

Pronotum twice as wide as long, somewhat wider at base than at apex, and widest at basal third; sides arcuately rounded; disc convex and without median depression; surface coarsely, somewhat densely punctate, moderately clothed with rather long recumbent whitish hairs, especially at the sides, and the intervals rather finely granulose. Scutellum triangular, granulose.

Elytra slightly wider than pronotum; sides nearly parallel from humeral angles to apical third, then narrowed to rounded apices; lateral margins finely serrate; basal and humeral depressions distinct; disc moderately convex, without discal foveae; surface densely coarsely punctate.

Prosternum sparsely coarsely punctate and rather densely clothed with long recumbent hairs; anterior margin with a broad short lobe. Anterior femur with a distinct tooth.

Length, 6.25 mm.; width, 2.48 mm. Paratype length, 5.97 mm.; width, 2.30 mm.

Female.—Differs from the male in having the front of head black with a slight bluish tinge, and in having the last visible abdominal sternite broadly rounded at apex.

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[1]Scientific Article A208. Contribution No. 2125 of the Maryland Agricultural Experiment Station (Department of Entomology).

Length, 6.54 mm.; width, 2.56 mm.

Type locality.—Starr County, Texas; 6½ miles southeast of Rio Grande City, beside the highway leading to Mission, Texas.

Type material.—Described from two male and one female specimens collected on living *Acacia rigidula* Benth. at the above locality April 12, and 19, 1947. Male type deposited in the U. S. National Museum (No. 58836); allotype and male paratype are in the writer's collection.

Comparison.—This abundantly distinct species runs to *lixa* Horn by Fisher's key[2] since it bears a tooth on the anterior femora. However, it otherwise seems to be closer to *cupreohumeralis* Van Dyke and *ephedrae* Knull, from which it may be readily recognized by the lines of pubescence on the elytra.

Agrilus exsapindi n. sp.

Fig. 7

Male.—Form of *obsoletoguttatus* Gory; head bronzy green to brassy green; pronotum and elytra varying from olivaceous cupreous to brownish cupreous and each elytron ornamented, vaguely, with yellowish pubescent spots, one in basal depression, one at basal third, an elongate one at apical third, and another at the apex, the latter two vaguely connected in better marked specimens; beneath more shining and the sides mostly covered with yellowish pubescence and efflorescence.

Head with front somewhat narrow, feebly convex, about equal in width from top to bottom, and with median groove feebly indicated; surface granulose, densely coarsely punctate, and sparsely clothed with recumbent yellowish pubescence; antennae extending to posterior angles of pronotum when laid along sides, and serrate from the fourth joint with the outer segments much longer than wide.

Pronotum broader than long, about as wide at base as at apex, widest near apex, sides obliquely narrowed from apex to behind middle then more strongly narrowed to base, the angle being quadrate; marginal and submarginal carinae sinuate, broadly separated at middle and connected at basal fourth; basal margin with median lobe deeply emarginate; disc convex, with two distinct median impressions and a broad oblique depression on each side, prehumeral carinae prominent, straight; surface rugose with sides near margins densely covered with pubescence and efflorescence. Scutellum transversely carinate.

Elytra slightly wider than pronotum at base; vaguely broadly constricted in front of middle, scarcely expanded posteriorly, with tips rounded separately and strongly serrulate; sides of abdomen narrowly exposed, anterior half covered with pubescence and efflorescence; disc flattened, each elytron with a rather distinct longitudinal costa and basal depressions; surface coarsely, irregularly, imbricate punctate and uniformly clothed with short recumbent yellowish pubescence.

Abdomen beneath finely sparsely, punctate, with rather long sparse recumbent pubescence, and with sides of the two basal segments and a large spot on the side of each of the remaining three segments densely clothed with recumbent yellowish pubescence and efflorescence; first two ventrals without median impression and with suture unindicated

[2]W. S. Fisher, U. S. Department of Agriculture Miscellaneous Publication No. 470, pp. 1-275, 1942.

at the sides; pygidium carinate, the carina not projecting. Sides of thorax densely covered with yellowish white pubescence and efflorescence; prosternal lobe shallowly emarginate. Tarsal claws simply cleft, with inner lobes of hind claws shorter and broader; tibiae straight.

Length, 7.88 mm; width, 1.68 mm.

Female.—Distinguished from the male in having the front and clypeus cupreous black and not granulose, in having the elytral markings more distinct, and in being more robust.

Length, 8.80 mm; width, 2.12 mm.

Type locality.—S. W. Hidalgo County, Texas; one mile south of Granjeno.

Type material.—Described from 24 male and 36 female specimens. Almost half of these were reared from a log of *Sapindus Drummondii* H. and A. and the others were collected on succulent foliage of this tree; March 29 through September 16, 1947. Type and four paratypes deposited in the U. S. National Museum (No. 58837); paratypes also deposited in the collections of the American Museum of National History and of J. N. Knull; allotype and remaining paratypes are in the writer's collection.

Variation.—In the series studied there was little variation except in size (males, 6.72–9.14 mm. and females, 6.43–10.3 mm.) and in definition of markings which on most specimens are quite vague, and this variation not being due to abrasion.

Comparison.—This species is allied to *obsoletoguttatus* Gory from which it may be easily distinguished by the form of its genitalia, its larger size, different color, more distinct elytral costae, and by the shallow emargination of the prosternal lobe.

Agrilus sapindicola n. sp.

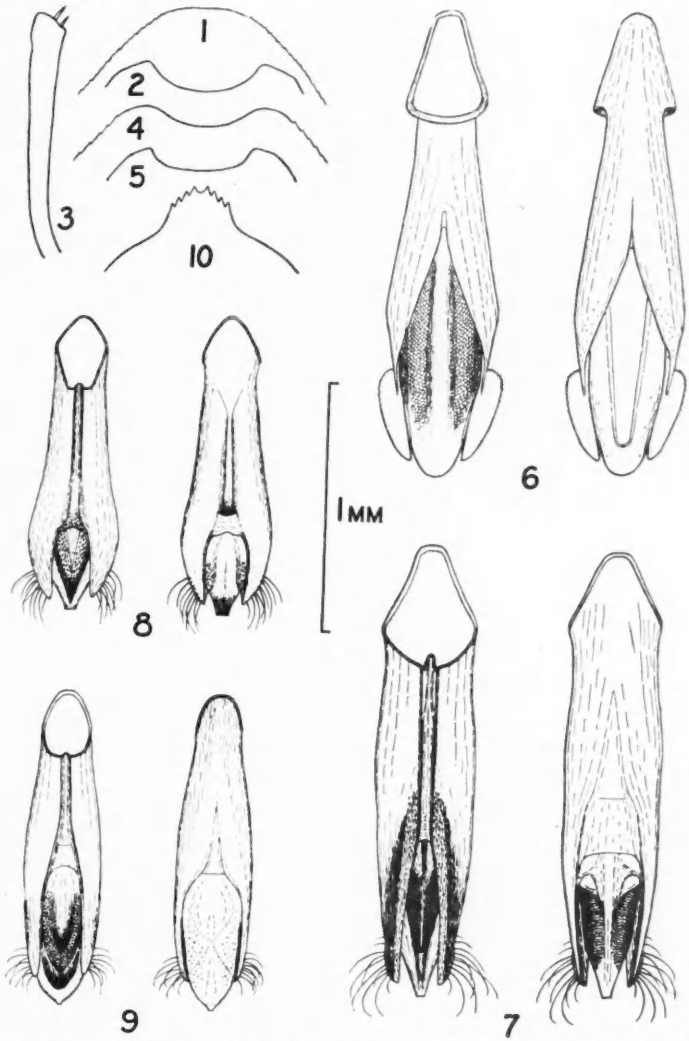
Fig. 8

Male,—Form of *obsoletoguttatus* Gory; head rather dull brassy green becoming brassy black on the occiput; pronotum and elytra shining black to bronzy black and ornamented with pubescent markings.

Head with front broad, almost flat, and with median depression feebly indicated; surface finely granulose and sparsely punctate becoming rugose on the occiput and with pubescence coarse and yellowish and limited to the clypeus, the lower portion of the front, and along inner margins of the eyes; antennae almost attaining the posterior angles of the pronotum, serrate from the fourth joint.

Pronotum broader than long, slightly narrower at base than at apex, widest near apex; sides obliquely narrowed from apex to basal third, then somewhat more strongly narrowed to the base, the angle being quadrate; marginal and submarginal carinae sinuate, somewhat broadly separated at middle and connected at basal third; basal margin with median lobe shallowly emarginate; disc convex, with two rather shallow median depressions and broad oblique depressions each side, prehumeral carinae short, divergent and indistinct; surface rugose with sides near margins densely white pubescent-efflorescent. Scutellum transversely carinate.

Elytra wider than pronotum at base, and slightly wider at base than behind middle; sides similar to those in *exsapindi* n. sp; sides of abdomen



In the case of male genitalia, the left hand figure represents the dorsal surface and the right hand figure represents the ventral surface.

Chrysobothris pubilineata n. sp. Fig. 1. Last sternite of female. Fig. 2. Clypeus of female. Fig. 3. Fore tibia of male. Fig. 4. Last sternite of male. Fig. 5. Clypeus of male. Fig. 6. Male genitalia.

Agrilus exsapindi n. sp. Fig. 7. Male genitalia.

Agrilus sapindicola n. sp. Fig. 8. Male genitalia.

Agrilus obscurilineatus n. sp. Fig. 9. Male genitalia.

Pachyschelus fisheri n. sp. Fig. 10. Sternal process of last sternite of female.

narrowly exposed above and with the anterior half white with pubescence-efflorescence; disc somewhat flattened and with moderately deep basal depressions; surface imbricate punctate, more or less pubescent with short white hairs except for a narrow stripe along the suture and a discoid patch at the apical third almost bare, and each elytron with denser hairs and efflorescence forming a spot in the basal depression, a short vitta extending from the basal fifth to the bare discoid area, and an elongate mark along the apical fourth.

Abdomen beneath brassy black to bronzy black, rather coarsely sparsely punctate, with sparse recumbent pubescence and with the sides of the second and fourth ventrals bearing a small pubescent spot and the sides of the third a rather large patch; first two ventrals without median impression and with the suture obliterated at the sides; pygidium carinate, the carina not projecting; the hind coxae and much of the undersurface of the thorax covered unevenly with white pubescence and efflorescence; prosternal lobe broadly, deeply emarginate. Tibiae slender, first and second pairs toothed at apex. Tarsal claws nearly similar on all feet, simply cleft with inner lobes broad.

Length, 5.17 mm; width, 1.20 mm.

Female.—May be distinguished from male on the following characteristics: first and second pairs of tibiae without tooth at apex; front less granulose; form more robust.

Length, 5.30 mm.; width, 1.33 mm.

Type locality.—S. W. Hidalgo County, Texas, one mile south of Granjeno.

Type material.—Described from 14 male and 6 female specimens, all collected on succulent foliage of *Sapindus Drummondii* H. and A., March 29-April 5, 1947. Type and three paratypes deposited in the U. S. National Museum (No. 58838); paratypes also deposited in the collections of the American Museum of Natural History and of J. N. Knull; allotype and remaining paratypes are in the writer's collection.

Variation.—In the series studied there is little variation except in sizes: males, 3.90–5.17 mm.; females, 4.75–5.54 mm.

Comparison.—By Fisher's key[3] this species runs to *obsoletoguttatus* Gory from which it may be distinguished by its size, markings and genitalia.

Agrilus obscurilineatus n. sp.

Fig. 9

Male.—Form elongate, subparallel, flattened above; head varying from dull olivaceous to dull bronze and becoming reddish cupreous on the occiput; pronotum and elytra uniformly bright reddish cupreous. Pronotum and elytra with a vague longitudinal white pubescent vitta.

Head with front broad, moderately convex, and wider at top than bottom, median depression slight; surface granulate becoming shallowly rugose on the occiput, sparsely clothed with short recumbent white pubescence. Antennae extending to basal fourth of pronotal margin, serrate from the fifth joint, the outer joints almost as wide as long.

Pronotum wider than long, widest near apex; margins gently nar-

[3]W. S. Fisher, U. S. National Museum Bulletin 145, pp. 1-347, 1928.

rowed to basal third, then more strongly narrowed to just before the base where they broaden slightly; when viewed from the sides, the marginal carina is sinuate, the submarginal carina nearly straight, the carinae widely separated anteriorly and connected to each other near base; disc moderately convex, with distinct median depression, with lateral depressions well marked, and with prehumeral carinae prominent and straight; surface granulose, transversely rugose at the middle, and lateral depressions clothed with short recumbent white pubescence-efflorescence. Scutellum transversely carinate.

Elytra about as wide as pronotum at base and about as wide at base as behind the middle; sides nearly parallel from base to apical third and then attenuate to tips which are separately rounded and serrulate; sides of abdomen narrowly exposed and white with pubescence and efflorescence; disc flattened with broad shallow basal impressions which extend posteriorly the length of the elytra as vague longitudinal impressions; surface finely densely imbricate punctate; pubescence short.

Abdomen beneath bright red cupreous, lightly punctured, and with sparse short pubescence; first two ventrals with a vague to moderately defined median depression; pygidium not carinate. Sides of thorax white with moderately long pubescence and efflorescence; prosternal lobe broad, declivous, and rounded. Posterior coxae with the posterior margin arcuately emarginate. Tibiae straight and slender, anterior pairs with an inconspicuous apical tooth. Tarsal claws similar on all feet, simply cleft.

Length, 5.04 mm.; width, 1.24 mm.

Female.—Differs from male in being more robust, and in having the head uniformly reddish cupreous. The basal angles of the pronotum are quadrate and the median ventral impression is absent on the first sternite.

Length, 6.44 mm.; width, 1.76 mm.

Type locality.—Starr County, Texas; 6½ miles southeast of Rio Grande City, beside the highway leading to Mission.

Type material.—Described from five male and two female specimens collected on foliage of *Acacia rigidula* Benth. at the above locality on April 12 and 19, 1947. Type and one female paratype deposited in U. S. National Museum (No. 58839); allotype and remaining paratypes are in the writer's collection.

Variation.—There are no significant variations except for a tendency for the upper surface to be violaceous in some specimens. Size: males, 5.04–5.59.; females, 6.44 mm.

Comparison.—By Fisher's key this species runs to *aeneocephalus* Fisher from which it may be readily distinguished by the genitalia, and by the form of the pronotal margins.

Pachyschelus fisheri n. sp.

Fig. 10

Female.—Broadly cuneate, broadest at base of pronotum, broadly arcuately narrowed from base of elytra; head and pronotum polished cupreous, with a vague pubescent fascia on each side at the base of the pronotum; scutellum and elytra bright metallic blue with a prominent pubescent fascia at apical third.

Head deflexed, front gibbose and broadly deeply excavate; surface with a few widely scattered punctures and hairs.

Pronotum three times wider than long at middle, much narrower at apex than at base, sides arcuately rounded from base to apex; base broadly deeply emarginate on either side of the scutellum, posterior angles slightly produced; surface impunctate except for the minute punctures bearing the sparsely distributed white setae. Scutellum triangular, smooth.

Elytra at base almost as broad as pronotum, widest at base; sides feebly obliquely narrowed to basal third, then arcuately narrowed to the tips which are conjointly rounded, lateral margins serrulate; disc moderately convex, each elytron with a shallow basal depression and a lateral excavation behind umbone; surface with moderate punctures arranged somewhat in rows and each bearing a fine seta.

Abdomen beneath bronzy black, minutely granulate and bearing a few short hairs; last segment narrowed and broadly produced downward at apex which is rounded and armed with eight rather uniform, stout teeth. Underside of thorax shining bronzy black and bearing a few scattered inconspicuous hairs; anterior margin of prosternum feebly arcuately emarginate; prosternal lobe wanting. Antennal grooves deep, wider at middle and not attaining lateral margins.

Length, 2.99 mm.; width, 1.70 mm.

Male.—Differs from female in the last sternite not being produced. Length, 2.95 mm.; width, 1.70 mm.

Type locality.—S. W. Cameron County, Texas. Three miles east of Santa Maria.

Type material.—Described from 5 female and 10 male specimens. Twelve of these were collected at the above locality on foliage of myrtle-leaf croton (*Bernardia myricaefolia* (Scheele) S. Wats.) June 8-September 13, 1946–47. The remaining three were reared from leaves of this shrub. Type and two paratypes deposited in the collection of the U. S. National Museum (No. 58840); paratypes also deposited in the collections of the American Museum of Natural History and of J. N. Knull; allotype and remaining paratypes are in the writers collection.

Variation.—No significant variations are noted in the series studied, except for size: females, 2.63–3.04 mm; males, 2.80–2.95 mm.

Comparison.—This very distinctive species seems closest to the Central American *P. pubicollis* Waterhouse[4] from which it may be readily separated on the basis of its larger size, less cuneate form, gibbose and excavate front, and by the prominence and configuration of the armature of the apical process of the last ventral segment of the female.

The writer takes pleasure in naming this beautiful species in honor of Mr. W. S. Fisher whose many published works have been a constant source of inspiration.

[4]See W. S. Fisher, Proceedings of the U. S. National Museum No. 2454, pp. 1–95, 1922.

NEW NORTH AMERICAN BEES OF THE GENUS DUFOUREA

(Apoidea—Halictidae)

PART III

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Four new species and two new subspecies of the genus *Dufourea* have come to light since parts I and II of the series under the above title were written. Addition of these plus the recognition of *D. spilura* (Ckll.) as a valid species raise the total number of recognized species of American *Dufourea* to sixty-one. It is probable that several more will be found within the next few years. This is especially likely in the Sierra Nevada and Coast Range mountains of California where large areas have been inadequately collected for bees from March to May.

Unless otherwise stated, holotypes and allotypes of the new bees herein described will be deposited at the California Academy of Sciences in San Francisco. Paratypes will be distributed to the following collections besides the author's: United States National Museum; University of California Citrus Experiment Station, Riverside, California; American Museum of Natural History, New York. When available, additional paratypes will be sent to other collections upon request.

Dufourea subdavidsoni n. sp.

Male.—Length about 9 mm., length of anterior wing 5 mm.; pubescence mostly white to pale testaceous but with hair on scape and the longer hairs on vertex and mesonotum mostly black; integument dark, with distinct bluish metallic reflections to entire body except legs, antennae, abdominal sternum, and apical borders of abdominal tergites. *Head:* Face length over breadth, five over six; eyes nearly parallel, the distance between them at antennal insertion nearly one-fourth greater than eye length; face viewed from in front with distance behind posterior ocellus at least twice as great as ocellar diameter; area between posterior ocellus and nearest point of eye shallowly concave; distance from antennal socket to clypeus about equal to socket diameter; clypeus nearly concealed by reclining whitish pubescence which is mostly longer than antennal scape; upper margin of clypeus and lower parietal region with similarly long but more erect black hair; punctures of frons and vertex coarse and dense, mostly separated by less than one-half a puncture diameter; antennae black to dark brown; scape flattened, about twice as broad as long, bearing long grey and a few long blackish hairs; flagellum as long as hind tibia and metatarsus together, the segments without long hairs and very slightly expanded subapically, fourth flagellar segment with basal two-thirds of upper side smooth; first flagellar segment two-thirds, second three-fourths and third quite

as broad as long; maxilla with stipes about as long as eye; galea beyond palpus about twice as long as broad and sharply pointed; maxillary palpus about half as long as stipes, first segment twice as long as broad, twice as long as second which is subequal to each of remaining segments; labial palpus three-fourths as long as maxillary, first segment three times as long as broad, twice as long as each of remaining, second segment as broad as first, twice as broad as succeeding segments; glossa shorter than labial palpus; mandible only slightly dilated along outer margin, about one-fourth as wide as distance from its apex to eye, its outer basal two-thirds bearing a dense tuft of yellowish hairs as long as the eye. *Thorax:* Mesoscutum, mesoscutellum coarsely, moderately closely punctured, the punctures on the average somewhat less than one puncture width apart except for central area of mesoscutum, the interpunctural areas polished; mesoscutum with short, sparse, whitish hair and long, sparse black hair which is about as long as antennal scape; hypoepimeral area of mesopleuron with about ten widely scattered punctures; wings definitely yellow-tinged, the first transverse cubital vein offset from the first recurrent by about half its own length; hind wing with seven hamuli; legs very slender, without swollen segments; hind leg with femur three times, tibia four times and metatarsus five times as long as their respective breadths; second and third hind tarsal segments slightly longer than broad and somewhat produced dorso-apically; ventral margin of hind tibia with dense fringe of whitish hairs ranging from about half as long to quite as long as tibia; outer face of metatarsus with scattered, very long hairs; hind tibial spurs long and slender, the inner one four-fifths as long as metatarsus and margined with close-set, needle-like teeth. *Propodeum:* Enclosure coarsely, evenly carinate, with about 12 carinae on either side of mid-line. *Abdomen:* Dorsal portions of tergites with punctures mostly slightly over one puncture width apart and entirely covered with whitish pubescence nearly concealing integument when viewed from in front; posterior tergite borders testaceous, with indistinct hair bands; sternites with distinct apical hair bands in addition to short, erect white hair on remainder of first four; posterolateral hooklets of fourth and fifth sternites represented by a minute swelling and a pit respectively; fourth and fifth sternites each with a discreet area of hair medially on a broadly rounded production of the apical margin which is otherwise broadly emarginate; sixth with a median depressed area bounded laterally by strong carinea and terminated apically by a transverse ridge which is almost at the gently emarginate apex of the segment; posterior arms of seventh broadly rounded apically, somewhat longer than their basal, ventral flaps, and each tipped with a hair tuft as long as the arm; posterior projection of eighth about two and one-half times as long as its basal breadth which is about three times as great as its apical breadth.

Female.—Length about 8.5 mm., length of anterior wing 5 mm.; slender in form with pubescence rather long, mostly yellowish white to testaceous but with numerous long sooty to blackish hairs on clypeus, scape, vertex, mesoscutum and posterior margins of apical tergites; integument with distinct bluish tinge on head and thorax but essentially black on clypeus and abdomen. *Head:* Face five-sixths as long as broad; inner eye margins parallel; eye length slightly over three-

fourths interocular width at antennal insertion; distance from antennal socket to clypeus about three-fourths socket diameter; distance from posterior ocellus to vertex about equal to ocellar diameter; hair on clypeus, lower portion of frons as long as apical fringe hairs of clypeus; clypeus with at least 50 punctures; punctures of frons mostly much closer than one puncture width apart except near ocelli; mouthparts (except mandibles) similar to those of holotype. *Thorax:* Mesoscutum with punctures of central half a little finer than those of frons and mostly separated by more than one puncture width; mesoscutellar punctures about one puncture width apart; hypoepimeron with lower half bare, upper half densely, coarsely punctured; dorsal vestiture testaceous and short except for numerous long, sooty hairs; hind wing with eight hamuli; posterior tibia over four times, posterior metatarsus over five times as long as their respective breadths; mid tibial spur uniformly testaceous; tibial scopa sparse, whitish ventrally, sooty dorsally. *Abdomen:* First tergite as long as broad and rather uniformly covered with fine punctures which are mostly several puncture widths apart; tergites with subapical hair fringes testaceous to sooty, sparse except on tergites five and six; anal fimbria reddish testaceous.

Holotype male, *allotype* female, 8 male and 3 female paratypes: Giant Forest, Tulare Co., Calif., July 16–26, 1923 (C. L. Fox). One male paratype, Tallac, Lake Tahoe, Calif., July 17, (1925?), (E. P. Van Duzee). I also have a female specimen from Gold Lake, Sierra Co., Calif., July 26, 1921 (C. L. Fox) which appears to be this rather than *D. scabricornis* n. sp.

One male specimen from Giant Forest has the first three antennal segments of about the same proportions as the other species of this group. Several of the males also have more black hair on the scape than has the holotype.

This species is very close to *D. davidsoni* (Ckll.), *D. spilura* (Ckll.), and *D. scabricornis* n. sp. The male may be distinguished readily from any of these by the gently emarginate apex of the sixth abdominal sternite. The female has sparser mesoscutal punctures than *D. davidsoni* or *D. spilura* and appears to have finer ones than *D. scabricornis* n. sp. It is probable, however, that some female specimens will prove to be indistinguishable.

Dufourea scabricornis n. sp.

Male.—Very close to holotype of *D. subdavidsoni* n. sp. but differing as follows. *Antennae:* Scape with black hairs more numerous and conspicuous than pale ones; upper side of fourth flagellar segment over one-half and eleventh about one-third roughened; first flagellar segment half, second two-thirds, and third five-sixths as broad as their respective lengths. *Mesoscutum:* punctures rather sparse and irregularly placed, often separated by two or more puncture widths peripherally as well as centrally. *Abdominal sternites:* fourth and fifth with apical hair fringes continuous but reduced sublaterally; sixth with median depressed area produced apically into a pair of projections separated by a V-shaped notch and with the subapical transverse ridge bounded laterally by a pair of bosses.

Female.—Very close to allotype of *D. subdavidsoni* but with punctures of mesoscutum considerably coarser than those of mesoscutellum.

Holotype male: Brockway, Lake Tahoe, Calif., elev. 6400 ft., July 10, 1941 (G. E. Bohart). *Allotype:* Jenny Lake, Grand Teton National Park, Wyo., July, 1937 (J. W. MacSwain). *Paratypes:* 1 male, Coffee Creek, Trinity Co., Calif., elev. 5500 ft., June 22, 1934 (T. H. Aitken); 1 male, Carrville, Trinity Co., Calif., elev., 2500 ft., June 15, 1934 (G. E. Bohart); 3 males (2 damaged) same as for allotype; 1 male, Timpanogos Mtn. near Provo, Utah, June 25, 1925 (A. L. Melander).

The specimen from Utah is slightly smaller than the others but otherwise the type series is very uniform.

This species is in a closely knit group with *D. davidsoni* (Ckll.), *D. spilura* (Ckll.) and *D. subdavidsoni* n. sp. The male can be distinguished from *D. spilura* by the absence of long hairs on the flagellum, from *D. davidsoni* by the smaller antennae, the greater extent of roughness on the fourth and last flagellar segments, and from *D. subdavidsoni* by the deeply V-shaped notch at the apical margin of the sixth abdominal sternite. It also differs from *D. spilura* and *D. davidsoni* in having relatively unexpanded mandibles, in which regard it resembles *D. subdavidsoni*. The female, represented by one specimen in poor condition, apparently has a more sparsely and coarsely punctured mesoscutum than the related species. There may be justification for considering the four species of this group as subspecies inasmuch as they are practically indistinguishable in the female sex and have fewer distinguishing characteristics in the male than is usual with *Dufourea*. However, no intergradation of essential characters has been found and the territories of at least three of them overlap. To my knowledge, two or more of these species have not been collected together.

Dufourea impunctata n. sp.

Male.—Length about 8 mm., length of anterior wing 4.5 mm.; pubescence wholly pale, mostly white; integument shining jet black, with no trace of bluish or greenish reflections. *Head:* Face length over breadth 5 over 5.5; eyes nearly parallel, very slightly convergent below, the distance between them at antennal sockets slightly greater than eye length; face, when viewed from front, with distance behind posterior ocellus nearly twice ocellar diameter; area laterad to posterior ocellus flattened; distance from antennal socket to clypeus slightly greater than socket diameter; clypeus, supraclypeal area largely concealed by dense, white pubescence, long and suberect on the former, prostrate on the latter except laterally; punctures of frons coarse, mostly separated by about one puncture width except for nearly impunctate areas surrounding ocelli; pubescence of frons, cheeks long, sparse, entirely pale; antennae black basally, dark brown above on last ten segments, about one-half as long as anterior wing, the flagellar segments not at all swollen medially, slightly broader than long except for last two which are longer than broad; underside of flagellum distinctly flattened, with several rows of pale hairs bent at their middles to right angles and about half as long as flagellar width; scape nearly as broad as long, covered with long white hair; maxillary stipes three-fourths as long as hind tibia; the galea beyond palpus about one-third as long as prepalpal portion and less than three times as long as broad; maxillary palpus five-sixths as long as stipes, the second segment about three times as

long as broad and one-third longer than any of others which are subequal; labial palpus about three-fourths as long as maxillary, the first segment equal to next two combined. *Thorax:* Mesoscutum polished, nearly impunctate except for fine scattered punctures anterior and lateral to parapsidal furrows; mesoscutellum more densely punctured but with punctures rather fine and mostly two or more puncture widths apart; mesoscutal and scutellar hair long, white, sparse, not at all concealing integument from any view; wings clear, without yellow or grey tinge, the veins pale testaceous; first recurrent vein offset from first transverse cubital by nearly its own length; hind wing with seven hamuli; legs somewhat swollen but without striking modifications; femora about half as broad as long, the first two broadest subbasally; hind tibia about two and three-fourths times as long as broad; hind metatarsus parallel-sided, about three and one-half times as long as broad; next three segments about as broad as long, slightly produced posteriorly; hind tibial spurs not over half as long as metatarsus, their margins with numerous, fine, close-set teeth. *Propodeum:* Enclosure strongly, evenly carinate throughout, with about 18 distinct carinae on either side of mid line; vertical posterior portion of enclosure smooth, without transverse carinae even at summit. *Abdomen:* Tergites with very sparse, setigerous punctures, the central two-thirds of the first almost impunctate; posterior tergite borders transparent, appearing black when closely applied to succeeding segments, and not preceded by distinct hair bands except for sparse ones on fifth and sixth tergites; sternites polished, with indistinct, fine pubescence except for that of apical borders where it forms a band of erect to recurved hairs on third and fourth segments; fourth also with a pair of strongly recurved hooklets posterolaterally; fifth evenly emarginate; sixth medially depressed, with a flat, subtriangular, apically truncate projection, about as broad as long, a little longer than antennal scape,and entirely covered with a long, dense tuft of yellowish hair; posterior arms of seventh with long hair tufts and about half as broad as their lengths beyond the basal flaps which have inner, apical, pointed extensions; apical projection of eighth with proximal half triangular, distal half nearly parallel-sided, less than one-fourth as broad as base.

Holotype male, 1 male *paratype*, "So. Cal." from the collection of the Philadelphia Academy of Sciences where the holotype will be deposited.

This is a very distinct species, probably related to *D. nudicornis* Timb. but easily separated by its non-crenulate antennal flagellum which bears bent hairs ventrally. Its non-metallic integument and sparse punctation distinguish it from species having similar antennae.

Dufourea convergens n. sp.

Male.—Length about 6 mm.; length of anterior wing 4.5 mm.; hair wholly pale, mostly white, rather long, not dense; integument dark greenish blue; body rather robust. *Head:* Face length over breadth 6 over 7.5; eyes distinctly convergent below, the distance between them at their lower margin three-fifths that at their extreme summits; eye length slightly less than distance between them at antennal insertions; clypeus over twice as broad as long, densely punctured, covered with

long, dense, reclining, white hair; supraclypeal area similarly punctured and haired; distance from antennal socket to clypeus about equal to socket diameter; hair of cheeks, frons, vertex white, long, quite sparse; frons, vertex moderately finely, closely punctured, the punctures mostly less than one puncture width apart, but somewhat sparser near ocelli; area between lateral ocellus and compound eye well rounded; face, viewed directly from in front, with distance behind lateral ocellus less than half ocellar diameter; antenna short, black to dark brown, flagellar segments, except first, as broad as or broader than long, the apical seven each slightly crenulate on outer side; scape rather flat, over twice as long as broad; flagellum bare except for usual minute general pubescence; maxilla with stipes about four-fifths as long as hind tibia; galea about one-third as long as stipes, narrowly rounded apically; maxillary palpus about two-thirds as long as stipes, first segment about three times as long as broad, a little longer than second, twice as long as any of remaining segments; labial palpus about half as long as stipes, first segment as long as next two combined. *Thorax:* Mesoscutum finely, rather densely punctured, the punctures somewhat less than one puncture width apart anteriorly and laterally, slightly more centrally, posteriorly; mesoscutum with short, white pubescence in addition to longer, sparser white hair (rather matted with moisture in available specimen); area above mesonotal spiracle bare ventrally, with about 15 fine punctures dorsally; thorax remarkably broad and deep for the genus; wings s ightly brownish, the first transverse cubital vein offset from first recurrent by two-thirds its own length; legs of moderate girth and not conspicuously modified; fore and mid femora over twice as long, hind femur thrice as long as broad; hind tibia four times as long as broad, nearly as broad apically as subapically, covered with white hair which is much shorter than tibial width; hind metatarsus five times as long as broad, the succeeding two segments each nearly twice as long as broad. *Propodeum:* Enclosure five times as broad as long, the median half with fine, irregular carinae, the lateral portions with rather widely spaced, regular carinae. *Abdomen:* First tergite highly polished, with rather numerous but very fine and widely separated punctures; succeeding tergites with subapical hair bands weakly developed, those of fourth and fifth scarcely distinct from general pubescence; apical tergite with a distinct narrow, bare pygidial area; sternites nearly bare, without sublateral hooklets or callosities; fourth and fifth sternites simply transverse on apical margins; sixth unmodified except for a very small, pointed but flat apical projection; apical lobes of seventh broadly rounded distally, the portions projecting beyond their basal, ventral flaps about as broad as long; apical projection of eighth slender nearly to extreme base, with the distal swelling, viewed from the side, shaped like a short foot with a well-developed instep; penis valves, viewed from the side, with free portions leaf-like, each about two-thirds as broad as long, highly arched dorsally, and extending for one-third its length beyond the gonostyli.

Holotype male (unique): San Diego, California (collector and date of collection unknown); from California Academy of Sciences collection.

This is in a small, compact group including *D. leachi* Timb. and *D. viridis* Timb. The group is easily distinguished in the male sex by

the relatively simple sixth sternite and by the globose genitalia. Females resemble members of the *D. sandhouseae* (Mich.) group quite closely. *D. convergens* may be separated from *D. viridis* by its blue instead of green color and by the foot-like structure at the apex of the eighth sternite. It may be separated from *D. leachi* by the eyes which are more strongly convergent below and by the penis valves which are more highly arched and extend considerably beyond the gonostyli.

Dufourea australis mexicana n. subsp.

Male.—Differs from *D. australis australis* (Mich.) and *D. australis dammersi* Timb. (new combination) in being smaller (body length 6 mm. and anterior wing length 4 mm. as against average measurements of 8 mm. body and 5 mm. wing for the other subspecies), and narrower (distance between tegulae 1 mm. as against an average of nearly 1.5 for the others). It also has a more nearly jet black ground color with the posterior tergite borders showing black instead of brown against the succeeding tergites. The vestiture is very sparse and that of the scape and paraocular areas has many sooty hairs in addition to white ones. Punctation is moderately sparse and fine, the punctures of mesoscutum and mesoscutellum being mostly separated by two or more puncture widths and those of the first apparent tergite by three or four.

Female.—Differs from the other subspecies in essentially the same characteristics as the male. Its body and wing length compare closely with the male's and its ground color, vestiture length and color, and punctation likewise differ from the other subspecies. It has closer punctation than the male, the punctures of the anterior half of the mesoscutum being slightly less than one and of the central portion about one puncture width apart. Punctation of females of the other subspecies is still closer. An additional difference exhibited by the female is the considerable amount of sooty mesoscutal pubescence.

Holotype male, *allotype* female, 8 paratype females and two paratype males, La Laguna, Sierra Laguna, Lower California, October 14, 1941, from a composite (G. E. Bohart and E. S. Ross).

This may represent a distinct species but its distinguishing characteristics of size, ground color, hair color, and density of punctation are usually considered of subspecific value. It seems to represent the small, dark, sparsely punctured extreme of a series of subspecies in which the other extreme is the relatively large, yellowish haired, densely punctured *D. australis australis*.

Dufourea sandhouseae arida n. subsp.

Male.—Differs from *D. sandhouseae sandhouseae* (Mich.) in having the hind tibia slightly less than one-third as broad as long (in the latter it is usually one-third or more) and in having a brighter yellow antennal flagellum. Punctures of the central portion of the mesoscutum are quite fine and average at least two puncture widths apart. In most males of *D. sandhouseae* s. str. the thoracic punctures are somewhat closer. The clypeus has a patch of long, erect hairs confined to the central portion whereas in most *D. sandhouseae* s. str. it occupies most of the clypeus.

Female.—Outer side of antennal flagellum reddish testaceous on

apical six segments instead of dark brown to dull yellowish brown as is the case with most *D. sandhouseae* s. str. As in the male, punctation is slightly finer.

Holotype male, *allotype* female, four male and two female paratypes: Westgard Pass Plateau, Inyo Co., Calif., May 27, 1937, from *Phacelia* (C. D. Michener). Other paratypes: one male, Westgard Pass, Calif., May 19, 1947 (R. M. Bohart); 1 male and females, Mt. Springs Cyn., Argus Mts., Inyo Co., Calif., elev. 5000 ft., May 22, 1937 (N. W. Frazier); 4 males, Palmdale, Los Angeles Co., Calif., April 11, 1936 (G. E., R. M. Bohart); 1 male, Baker, Calif., March 15, 1935; 1 male, Poway, Calif., March 22, 1890 (F. E. Blaisdell).

This subspecies represents an arid type. Intermediate specimens are found in the inner Coast Ranges (Priest Valley, Monterey Co., Calif.) and occasionally in any area largely populated by distinctive members of one or the other subspecies. Antennal flagellar color of the males from Inyo County varies from reddish yellow to a rather pale yellow but does not assume the dull brownish yellow typical of the more coastal form. Females of *D. s. arida* are apt to be confused with females of *D. malacothricis* Timb. in whose territory they are frequently found. The latter differ principally in having very fine and rather sparse mesonotal punctures.

THE LARVAE OF INSECTS, PART I, LEPIDOPTERA AND HYMENOPTERA, by ALVAH PETERSON. 315 pp., 84 plates. Lithoprinted, Edwards Brothers, Inc. 1948. Price, $5.00.

As important as the identification of immature insects is, this field of study has been badly neglected, and even the appearance of some important recent work has not attoned for the deficiency. So far, we have had no comprehensive manual for the identification of immature forms. The appearance of Dr. Peterson's work, therefore, is very welcome.

The present volume, the first of two parts, presents an introduction to the subject, with a discussion of collecting, killing, dissecting, and preserving methods and a description of the techniques of inflating and restoring larvae. Keys are given to the immature stages, excluding eggs, of all important orders, and a selected list of references is presented. Two orders, the Lepidoptera and the phytophagous Hymenoptera, are considered in detail, with keys, family characterizations, and lists of citations. A glossary and host indices, in addition to the general index, will increase the usefulness of the work.

The plates of illustrations have reproduced well. The scheme of numbering is interesting: plates O1 through O14 illustrate the orders in general, plates L1 through L58 the Lepidoptera, and plates H1 through H12 the Hymenoptera. The descriptive material accompanying each plate attempts to point out the distinctive morphological characteristics of the form illustrated and, in cases involving a definite species, other useful information is given.

The work has been tested through use, in preliminary form, by Dr. Peterson's students in his course in larval taxonomy. It impresses one as a well prepared manual, and minor criticisms that one might have of it seem trivial. We are anxiously anticipating the appearance of Part II, which, according to the statement in the introduction, is to deal with the Coleoptera, Diptera, Siphonaptera, Neuroptera, Trichoptera, and Mecoptera.—M. T. J.

A LABORATORY METHOD FOR REARING COCKROACHES, AND ITS APPLICATION TO DIETARY STUDIES ON THE GERMAN ROACH[1, 2]

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Cockroaches are popular insects for experimental studies, for they are readily available, of a convenient size, and grow at all seasons of the year. Their method of reproduction is such that a large number of nymphs hatch at once, making them ideal experimental animals for comparative quantitative studies. It is surprising, therefore, that no standard methods of rearing these insects have come into general use. A review of the more common methods of laboratory culture was presented by Campbell and Moulton (1943).

Various materials have been used as maintenance diets for stock colonies of cockroaches. For the German roach, *Blattella germanica* (L.), McCay and Melampy (1937) employed a mixture of ground whole wheat, dried skim milk powder and dry baker's yeast. Gould and Deay (1940) used "Pablum baby food, pulverized dog biscuit or Haydak's laboratory food." For the American roach, *Periplaneta americana* (L.), Griffiths and Tauber (1942) used "a diet of whole wheat bread, banana, and raw beef," while Gier (1947) used miscellaneous foods including "raw potatoes supplemented monthly with a little raw lean meat or unassorted table scraps." No quantitative studies on the relative effectiveness of these stock diets have been reported.

Environmental factors have been studied in more detail. Biometric data on the German cockroach were reported by Woodruff (1938, 1939), while similar studies were made on the American species by Gier (1947). The effect of temperature on the rate of development of five species of cockroaches was reported by Gould and Deay (1940), and by Gould (1941), who found that raising the temperature from 25° to 30° C. shortened the hatching period of the German roach from 28 to 17 days, and the nymphal period from 103 to 74 days. A temperature higher than 30° was unsatisfactory because of increased mortality.

Under ordinary conditions fluctuations in relative humidity seem to have no harmful effects. Thus, Gier (1947) noted no seasonal differences in hatchability of *P. americana* egg-sacs maintained in an incubator at 30° C. over a period of three years at a "reasonable humidity;" Gould and Deay (1940) recorded changes in relative humidity ranging from a low of 10 per cent in the winter to very high values in summer with no reported ill effects. However, a "humidity preference" was

[1]A portion of this paper was presented December 28, 1947, at the annual meeting of the Entomological Society of America, held at Chicago, Illinois.

[2]Published with the approval of the Director of the Wisconsin Agricultural Experiment Station. Supported in part by the Research Committee of the Graduate School from funds supplied by the Wisconsin Alumni Research Foundation.

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demonstrated by Gunn (1931, 1934) and Gunn and Cosway (1938) for the Oriental cockroach, which was influenced by the temperature, and hence, the drying capacity of the air.

Necheles (1927) observed that changes in light did not affect the activity of *P. americana* or *Blatta orientalis* (L.) directly, although it is common knowledge that cockroaches prefer to come out after dark to feed, remaining in hiding during the day. There is no startle reaction when roaches are suddenly exposed to light, as may readily be observed.

Nymphs of *B. germanica* reared in isolation were found by Pettit (1940) to require a longer period of time to reach maturity than nymphs reared in groups. A crowding effect was observed in *B. orientalis* by Landowski (1938) who reported an increased mortality, a shortened nymphal period, and a smaller adult size as a result of increasing the density of population in small containers. Similarly Griffiths and Tauber (1942) recorded a poorer reproductive performance of mating pairs of *P. americana* reared in small containers as compared to those in larger containers.

Sexual and genetic influences on the growth rate have received some attention. Gier (1947) reported that female nymphs of *P. americana* became significantly heavier than the males only after the last nymphal moult, and that the number of moults was the same for both sexes. Griffiths and Tauber (1942) have suggested that local "strains" of the American roach may have quite different growth rates, thus accounting for some of the wide variations in growth rate reported in the literature for this species.

A considerable degree of individual variation in growth rate has been reported. Gould and Deay (1940) recorded a variation in nymphal development of *B. germanica* from 37 to 127 days, with an average of 74 days, when reared at a constant temperature of 30° C. Similarly, Gier (1947) reported variations in the time of the imaginal moult within a group of nymphs of *P. americana* reared for growth studies from 200 to 430 days.

The method described below has been developed for the study of the nutritional requirements of the cockroach *B. germanica*. Since this method has yielded quantitative and reproducible results over a period of more than a year in testing some 300 synthetic diets, and since other physiological studies may be made by the same procedures, the techniques are described in detail.

EQUIPMENT AND PROCEDURES

Apparatus.—The standard rearing unit illustrated in fig. 1 consisted of a group of test tube cages arranged on a rack, with the horizontal tubes spaced by a strip of tin folded into loops, and the vertical tubes spaced by means of furniture nails. The individual rearing cage consisted essentially of three test tubes of different sizes. The large horizontal chamber was made from a 25 x 200 mm. test tube with the rounded end cut off and replaced by a fine (50 meshes per inch) wire cloth. The latter was sealed to the cut end with an adhesive consisting of a 1 : 1 mixture of beeswax and rosin. The feeder was a 10 x 50 mm. test tube placed with the open end toward the screen after being half-filled with the diet. The water reservoir was an 18 x 150 mm. test tube

resting against the rack in an inverted position. The watering tube was made from a piece of 8 mm. glass tubing 12 cm. long, bent in the middle at an angle of 120 degrees. To prevent this tube from leaking the lower end was heated until the opening had constricted to a diameter of 3 mm. The hole receiving this tube was bored in the large (No. 4) rubber stopper at an angle of 30 degrees to its midline, and the stopper beveled at the lower surface to allow the watering tube to project slightly from the stopper. A small (No. 1) rubber stopper served to connect the watering tube with the reservoir.

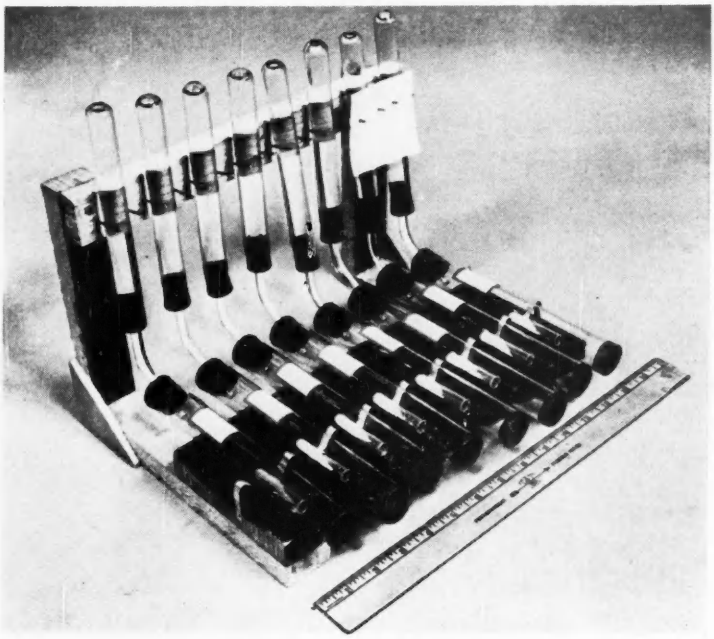

FIG. 1. The standard rearing unit for *Blattella germanica*.

Three modifications of this basic design have been used. One intended for dietary expriments on mineral requirements in which the metallic screen, a possible source of contamination, was replaced by a "chimney" plugged with cotton, is shown in fig. 2, center. A further modification (not illustrated) has been used in attempts to rear *B. germanica* under sterile conditions. In this design both rubber stoppers were eliminated by sealing the watering unit directly to the horizontal cage. The open end of the cage was plugged with cotton, and the upper end of the water reservoir was closed with a hypodermic stopper through which sterile water was injected with a syringe. The entire assembly,

including the diet, was autoclaved before the introduction of a sterilized ootheca.

An oversize modification of the cotton-plugged cage described above has been used in preliminary experiments with *P. americana* and *B. orientalis*. It is shown in fig. 2, left. The horizontal cage consists of a 38 x 200 mm. test tube for both species. The feeder for the American roach should be 20 mm. in diameter, while a 16 mm. feeder is adequate for the Oriental roach.

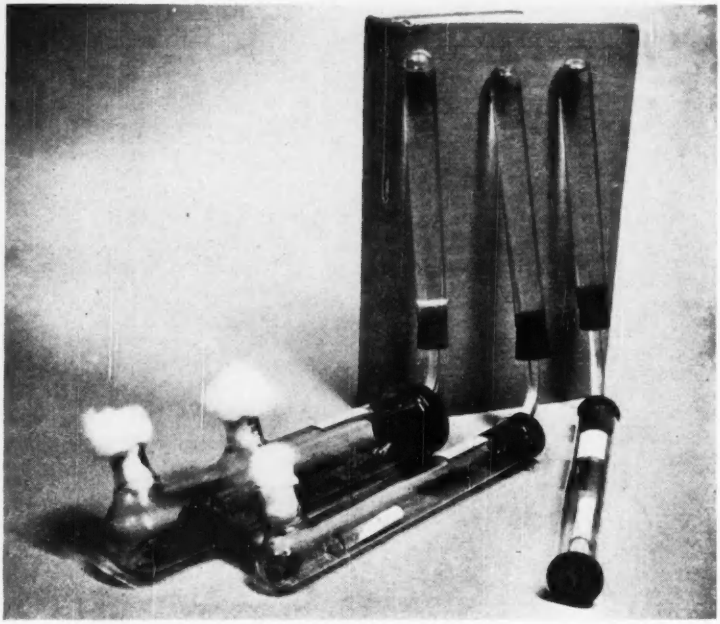

FIG. 2. Three types of rearing cages for cockroaches. Right to left: standard rearing cage for *B. germanica;* cotton-plugged cage for use in studies on mineral requirements; oversize modification used for *P. americana* and *B. orientalis*.

Rearing room.—The cages were kept on shelves in the anteroom of a 39° C. incubator. The temperature was subject to daily fluctuations from 26°C. to 33°C., with an average of about 30°C. The humidity was uncontrolled.

Stock colony.—The stock colony of *B. germanica* was maintained in the screened cages described above, with one mating pair per cage. At weekly intervals the diet, consisting of pulverized dog biscuits and water, was renewed. Data on the number of egg-sacs produced and the number hatching from each egg-sac were obtained by daily observations. A systematic breeding program has been followed for the purpose of standardizing the strain.

NUTRITION EXPERIMENTS

For a typical dietary experiment a hatching of day-old nymphs was distributed among the eight cages of a rack, allowing about 5 nymphs to a cage. The control group was fed pulverized dog biscuits, and the remaining seven groups were fed synthetic diets. The growth response ordinarily was compared only among the groups of one rack. Also, over a period of time, the growth response to the control diet could be compared for a series of successive experiments, as described below. At weekly intervals each of the feeders was replaced and the water renewed. The experimental diets were kept in a refrigerator at all times. The rate of growth was measured by weighing each group to within 0.5 mg. at ages of 10, 20 and 30 days. Weighings were made after anaesthesia with carbon dioxide. Nitrogen, ether and chloroform have been found by experiment to be much inferior to carbon dioxide as anaesthetics for *B. germanica*. A daily record was kept of the age and sex of maturing individuals. Selected groups were saved for obtaining data on reproduction.

Experimental diets.—Two crude diets and two synthetic diets which have been fed often enough as control diets to yield data on the reproducibility of growth response of *B. germanica* (Table I) have the following compositions:

CRUDE I	Per cent
[3]Pulverized dog biscuits	100

CRUDE II	Parts
[3]pulverized dog biscuits	95
corn oil	5
cholesterol	0.1

SYNTHETIC I	Per cent
glucose monohydrate	74
casein (alcohol extracted)	15
corn oil	5
[4]Wesson's salt mixture	4
cholesterol	1
L-cystine	0.6
[5]vitamin mixture	0.4

SYNTHETIC II	Per cent
glucose monohydrate	61.6
casein (alcohol extracted)	30
corn oil	3
[4]Wesson's salt mixture	4
cholesterol	1
[5]vitamin mixture	0.4

[3]Friskies brand. Manufactured by Albers Milling Company, Peoria, Illinois.

[4]Wesson, L. G., Science *75*, 339 (1932).

[5]*Vitamin*	micrograms/hram		micrograms/gram
thiamine HCl	12	Choline Cl	1000
riboflavin	18	inositol	2000
pyridoxine HCl	16	vitamin K (menadione)	1
nicotinic acid	100	biotin	0.6
calcium pantothenate	40	folic acid	5
para-aminobenzoic acid	50		

TABLE I

REPRODUCIBILITY OF GROWTH RESPONSES OF *B. germanica* NYMPHS REARED ON FOUR DIFFERENT DIETS

(Data assembled from 25 separate experiments.)

DIET	DATE	STRAIN	WEIGHT IN MILLIGRAMS		MATURITY, DAYS		TEMPERATURE, DEGREES C.	SEX	
			20 days	30 days	Average	Range	Average	M.	F.
Crude I	1-2	B	18	32	44	42-49	29.0	2	2
	1-10	A	19	44	40	38-42	29.2	2	2
	1-15	B	21	43	39	34-42	29.2	4	1
	1-18	B	20	48	39	33-45	29.6	4	3
	2-6	B	20	36	41	40-42	29.7	4	1
	11-23	B	25	50	38	35-41	29.6	2	3
	Average		20	42±4.6	40±2.0		29.4		
	Standard deviation of males			= 40.2 ± 3.1					
	Standard deviation of females			= 39.6 ± 2.0					
Crude II	10-23	I_4	...	34	42	41-42	28.7	2	2
	10-30	B	...	55	35	32-37	28.7	2	4
	11-4	B	...	64	34	31-36	29.0	1	5
	11-8	W	...	39	39	33-42	29.0	6	1
	11-14	W	20	46	39	35-45	29.3	3	2
	11-23	B	19	44	38	35-41	29.6	2	3
	11-29	W	11	...	43	41-45	29.7	3	2
	12-8	B	17	31	42	41-43	29.0	2	1
	Average		17	45±10.8	39±3.1		29.1		
	Standard deviation of males			= 39.8 ± 3.5					
	Standard deviation of females			= 37.2 ± 3.0					
Synthetic I	2-11	W	11	18	57	54-63	29.0	3	2
	5-4	W	...	22	57	52-64	28.9	3	2
	5-4	W	...	24	53	47-58	28.9	2	3
	5-4	W	...	20	61	48-84	29.3	4	1
	10-30	B	...	39	47	39-50	29.0	0	4
	Average		...	25±7.5	55±4.7		29.0		
	Standard deviation of males			= 57.5 ± 9.1					
	Standard deviation of females			= 53.4 ± 6.2					
Synthetic II	1-2	B	17	32	44	40-50	29.0	3	2
	1-15	B	11	23	51	49-57	29.2	3	2
	1-18	B	14	26	48	44-50	29.6	0	4
	2-6	B	11	21	50	49-53	30.0	2	2
	11-29	W	10	17	54	45-60	29.2	3	4
	12-8	B	14	31	48	44-50	29.1	2	4
	Average		13	25±5.3	49±3.1		29.3		
	Standard deviation of males			= 49.0 ± 4.2					
	Standard deviation of females			= 50.0 ± 5.2					

RESULTS

The growth responses of *B. germanica* nymphs to the four diets listed above are presented in Table I. Each of these diets was used as a control for separate experiments set up at different times. Results from 25 experiments are listed.

Roaches fed the crude diets matured in an average of 40 days, in contrast to 74 days recorded by Gould (1941) for this species reared under similar conditions. However, maturation was delayed on the two synthetic diets. The average age at maturity was 55 days on synthetic diet I (range 47–61 days for separate groups), and 49 days (range 44–54) on synthetic diet II. The average weights at 30 days were 42 and 45 mg., respectively, on the two crude diets, as compared with 25 mg. on the two synthetic diets.

The month and day at which each experiment was started is listed in the second column of Table I. No consistent variations in growth rate could be attributed to seasonal effects.

Column three of Table I lists four strains of *B. germanica* which were used in dietary experiments. Strain W represents nymphs which hatched from eggs of wild adults captured in the laboratory of the Biochemistry Building at the University of Wisconsin. Strain A adults were captured in the basement of a grocery store in Madison, Wisconsin, and strain B adults were captured in a bar located in another part of the city. Strain I_4 is the fourth inbred generation from the W strain. There were no consistent differences in growth rate noted which could be correlated with the different strains. However, the young of inbred group I_4 matured within a period of 2 days, in contrast with much greater ranges in time of maturity for the other three groups. A tendency toward greater uniformity in inbred strains has also been recorded in several other experiments not reported here.

The weights of the nymphs at 20 days listed in column four of Table I have not been used as the main criteria of growth response, since these weights do not always parallel the weights at 30 days or the age at maturity. However, a weight at 20 days is sometimes useful in dietary experiments in which an indication of the shape of the growth curve is desired. Furthermore the growth at this time is often helpful in planning the next experiment.

Two criteria of growth, weight at 30 days and age at maturity, columns five and six of Table I, were analyzed for variability and the standard deviation was calculated for each of the four diets. The standard deviation in age at maturity was ± 2.0 days and ± 3.1 days, respectively, for the crude diets, and ± 4.7 days and ± 3.1 days, respectively, for the synthetic diets. The corresponding standard deviations in weights at 30 days were ± 4.6 mg., ± 10.8 mg., ± 7.5 mg., and ± 5.3 mg., respectively. Hence the weight data were appreciably more variable than the data on maturation. Sex probably is an important contributing factor to the high variability in weight at 30 days, since the adult females weigh roughly one-third more than adult males. The two sexes, however, mature at approximately the same rate, as indicated by statistical analysis of the data on 64 males and 64 females in the 25 groups presented. This similarity between sexes was noted on each of the four diets tested. The standard deviation in the age of maturity for each sex tended to be greater than the overall standard

deviation for the group. This indicates that sex has little or no effect on the speed of maturation. Hence data on age at maturity are very useful in estimating the overall biological performance of *B. germanica*, as modified by diet.

SUMMARY

1. An apparatus and method are described for rearing groups of the cockroach *Blattella germanica* (L.) in comparative quantitative studies. An oversize modification of the apparatus has been found suitable for two other species of roaches.

2. Groups of *B. germanica* nymphs fed two crude diets matured at an average of 40 days ± 2.0 days, and 39 days ± 3.1 days, respectively. Nymphs fed two synthetic diets matured at an average of 55 days ± 4.7 days, and 49 days ± 3.1 days, respectively.

3. Seasonal and genetic variations in growth rate were not significant. However, growth appeared to be more uniform in inbred strains, as compared with first generation insects from natural populations.

4. The average weight of nymphs at 30 days showed roughly twice the variability of the average age at maturity, probably because of sexual differences in weight.

5. The average age at maturity is a useful index of biological performance of *B. germanica*, and it is not significantly affected by sex.

ACKNOWLEDGMENT

The photographs of the apparatus were taken by Carol Nieland.

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A STUDY OF THE GENUS GESOMYRMEX MAYR, AND A DESCRIPTION OF A SPECIES NEW TO THE GENUS

(Hymenoptera: Formicidae)[1]

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The genus *Gesomyrmex* is of particular interest to the myrmecologist because only four living species and one variety have been known and these very rare insects probably represent "vanishing relicts of a group of Formicidae with huge eyes and 8-jointed antennae which was represented by numerous species during the Oligocene and Miocene Tertiary." (Wheeler, 1921, p. 114)

The genus *Gesomyrmex* was established by Mayr (1868, p. 50) for a single species, *hoernesi*, obtained from Baltic amber. Emery (1891, p. 581) described as new *G. corniger* from worker specimens in Sicilian amber. However Wheeler (1914, p. 111) showed that Emery's specimens, which are armed with long spines on head and thorax, are generically distinct from *Gesomyrmex*, and he erected for them the genus *Sicelomyrmex*. André (1892, p. 47) described a living species of *Gesomyrmex*, which he named *chaperi*, collected from the Kapoewas Basin, North Borneo. André (1892, p. 49) described a larger form with a more rectangular head and smaller eyes from the Kapoewas Basin and erected for it a new genus, *Dimorphomyrmex*, naming the genotype *D. janeti*. Emery (1905, p. 188) described from Baltic amber a form closely related to *D. janeti*, which he named *D. theryi*. Wheeler (1914, p. 107) described *G. annectens* and *D. mayri* from Baltic amber. The same author (1916, p. 16) described a single alate female from Luzon, P. I. and named it *D. luzonensis*.

From two workers collected near Canton, China, Wheeler (1929, p. 112) described *G. howardi*. Wheeler (1929, p. 2) described *G. kalshoveni* from 15 workers (4 maximae, 8 mediae, and 3 minimae) which had been collected in a teak forest at Semerang, Java. In this paper Wheeler states (p. 2) that "the new species from Java now shows that the specimens of *howardi* are really media and minima workers, that those of *G. hoernesi* and *chaperi*, described by Mayr and André are minimae, that those of *D. janeti* are maximae and mediae of *G. chaperi*, and that the workers of *D. theryi*, *D. mayri* and *G. annectens* are in all probability the maximae, large mediae and small mediae respectively of *G. hoernesi*." Wheeler (1930, p. 35) described *G. luzonensis* var. *chapmani* from a series of 43 workers[2], a single female, and a single male from Dumaguete, Negros Oriental, P. I. In this paper Wheeler had to compare the workers of the new variety with those of *G. kalshoveni*, inasmuch as the typical *luzonensis* is known only from the female.

I have been unable to find in the literature subsequent to 1930

[1]Contribution No. 18, Department of Zoology and Entomology, University of Tennessee.

[2]The number in each caste is not specified.

further references to either collections or descriptions of forms of *Gesomyrmex*. In my collections of Indian ants I have found a series of *Gesomyrmex* workers which are apparently representative of a new species. A description and figure follow.

Gesomyrmex spatulatus n. sp.

Holotype, major worker (Pinned specimen, Cole collection No. A-136).—Overall length of body, 5.09 mm.; length of head, excluding mandibles, 1.27 mm.; length of thorax, 1.97 mm.; length of gaster, 1.85 mm.

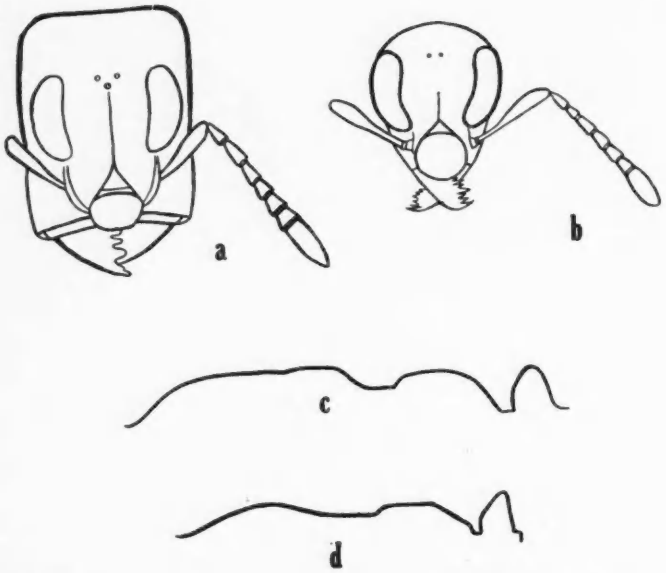

FIG. 1. *Gesomyrmex spatulatus* n. sp. a, head of major worker; b, head of minor worker; c, thoracic profile of major worker; d, thoracic profile of minor worker.

Head, excluding the mandibles, distinctly longer than broad, rectangular, only very slightly broader behind than in front; the sides subparallel, slightly concave in front of the middle; posterior corners sharply rounded; posterior border nearly straight; occipital margin broadly and arcuately excized; gular surface rather flat. Eyes large, elliptical, approximately twice as long as broad, slightly narrower anteriorly than posteriorly, located dorsad to the middle of the genae, the distance from the upper eye margin to the upper border of the head more than twice that from the lower eye margin to the antennal insertion. Lateral ocelli minute but distinct, unpigmented; median ocellus even smaller, indistinct. Mandibles rather flat, broad, the inner

border concave, the outer border convex; apical tooth short, broad, blunt; other teeth short, broad, rather blunt, and crowded. Clypeus subhexagonal, broader than long, flattened, ecarinate, rather triangularly depressed just below the middle; anterior margin broad, subtruncate, slightly but not distinctly covering the inner margins of the mandibles when they are in repose. Frontal area large, triangular, distinct, its angles nearly equal. Frontal groove distinct, rather deep in its central portion, extending from upper corner of frontal area to just below the lateral ocelli. Frontal carinae distinct, extending from the lateral clypeal margins to the lower borders of the compound eyes, broader in the middle, deflected laterally and obscuring the antennal insertions. Antennae short, eight-jointed; scape rather sharply incrassated from the middle apically, its distal end extending to a little more than half the length of the compound eyes, its apex a little more than twice the width of its base; funiculi with the first three segments longer and more slender than the remaining segments (except the terminal segment) which become increasingly broader apically; terminal segment longest of all and slightly broader than the penultimate segment, rather pointed, forming the end of a rather indistinct club.

Thorax long and slender, broadest through the pronotum, much narrowed at the mesonotum; pronotum seen from above elliptical, the length and breadth subequal; pronotum seen from the side evenly and broadly convex, except for the anterior declivity which is rather steep and slightly concave near its base; promesonotal impression shallow; constriction between mesonotum and epinotum broad, flattened, bearing on each side a tubercle supporting a spiracle; upper surface of epinotum extending above the mesoepinotal impression, slightly convex, a little longer than the rather steeply sloping, flat, posterior declivity, bearing on each side a large, posteriorly directed spiracle; mesonotum as broad as long, about half as broad as the pronotum; epinotum longer than broad, a little narrower than the pronotum. Petiolar node a little higher than the epinotum, its anterior surface convex, its posterior surface more flattened and declining posteriorly from apex to base where it joins the keel-like margin of the petiole; its superior border broadly but very distinctly emarginate, the excision continuing as a shallow groove along the middle of the anterior surface of the node; seen from behind broader above than below, with rather sharply rounded superior corners. Ventral surface of petiole when seen from the side with a longitudinally elongated, broadly convex lobe. Legs with all femora distinctly incrassated at the base; tarsal claws slender, distinctly curved, sharp at their tips.

Gaster rather large, elliptical.

Entire body shining. Head and petiole very sparsely and finely punctate; mandibles with more pronounced punctures; pronotum densely and finely foveate-punctate; mesonotum, mesoepinatal impression, and epinotum densely and rather coarsely foveate-punctate. Mandibles, clypeus, front of head, fore coxae, and posterior declivity of mesonotum (near the mesoepinotal impression) with rather coarse, irregular, longitudinal striae. What appear to be striae on the epinotum and the coxae of mid and hind legs are merely internal structures visible through the semitransparent integument.

Hairs yellow; long and pointed on the antennae (sparse and oblique on scapes, rather numerous on funiculi) long, numerous, and clavate with spatulate tips on upper surface of mandibles and on clypeus; long, slender, sharp, and rather numerous on lower surface of mandibles; long, sparse, and clavate-spatulate between upper margin of clypeus and lower margin of eyes; long, slender, pointed, and rather numerous on gula, becoming clavate-spatulate anteriorly; short, pointed, and abundant on palpi; long, slender, sharp, and rather sparse on ventral surface of pronotum, on coxae, petiole, and gaster, and on dorsal, apical margins of fourth and fifth gastric segments; a row of a few long, slender, pointed hairs on ventrolateral margins of petiole, and a row on each posteriolateral margin of epinotum; slender, pointed, and very sparse on trochanters and femora; absent from upper surface, sides, posterior margin, and posterior corners of head, from dorsal surface of thorax and petiole, and from most of the gaster. Pubescence very short, sparse, and indistinct.

General color of body yellowish brown; legs paler; clypeus (except its anterior margin), antennal scapes, and the striated region around the frontal area more whitish; a semicircle of brown extending across the posterior head margin and into the upper eye margins; mandibular teeth very dark brown; median portion of clypeus with a faint longitudinal band of light brown; mandibles, anterior clypeal border, and antennal carinae light brown; eyes distinctly violaceous. Dorsum of pronotum light brown with a V-shaped lighter area medially, the apex of the V pointing forward; dorsum of epinotum light brown; dorsum of gastric segments light brown, basal portion of first segment and lateral margin of each succeeding segment whitish; tarsal claws reddish brown.

Paratypes, minor workers.—Combined lengths of head and thorax of each of the 7 specimens are as follows: 1.94, 2.12, 2.30, 2.31, 2.33, 2.33, and 2.33 mm. The minors differ from the majors in the following characteristics: Size smaller; head not rectangular, much narrower anteriorly than posteriorly, its posterior border convex, its posterior corners not angular; eyes much larger in proportion to head size and more bulging; clypeus longer and projecting much farther forward over the mandibles, its anterior border arcuate instead of subtruncate, with a median longitudinal convexity; frontal area, frontal groove, and lateral ocelli much less pronounced; frontal carinae short and indistinct; median ocellus absent; mandibles narrower, greatly arched (that is, their lower surfaces greatly concave) their teeth longer and sharper, the apical tooth especially so; antennal scapes proportionally longer and more slender; mesonotum less convex in profile; dorsal surface of epinotum more flattened in profile, its posterior declivity straighter; a low, longitudinal, keel-like elevation along each dorsolateral margin of the mesoepinotal impression; petiolar node slightly less deeply excized along its superior border; pilosity very scarce and clavate-spatulate hairs absent; colored a more uniform yellowish brown.

Paratypes, intermediate workers.—Combined lengths of head and thorax of each of the 15 specimens are as follows: 2.37, 2.40, 2.51, 2.51, 2.51, 2.53, 2.59, 2.59, 2.59, 2.62, 2.62, 2.64, 2.64, 2.69, and 2.69 mm. Resembling the minors except in size; distinctly less bulging eyes; less anteriorly projecting clypeus; narrower mandibles; less broadly

convex posterior head corners and margin; more pronounced frontal carinae, frontal groove, and ocelli; and presence of a few scattered clavate-spatulate hairs on clypeus and gula.

Paratypes, major workers.—Combined lengths of head and thorax of each of the 2 specimens are 2.81 and 2.87 mm. Resembling the holotype except for their slightly smaller size and absence of prominent brown areas on head and thorax. The eyes are black in these alcoholic specimens, but they become violaceous when dry.

Described from a series of 25 workers collected by the writer at Jorhat, Upper Assam, India, February 22, 1944. The ants were running up and down on the trunk of a tall tree located in a sunny area beside a rice paddy. They were very agile and ran swiftly with a jerky motion. There were indications that the nest was arboreal, although there was no actual evidence to substantiate this view. The writer spent nearly four hours collecting the series of workers which were extremely scarce. Wheeler (1921, p. 115) states that "the thickened bases of the femora of *G. howardi* indicate that this ant can jump like the large-eyed *Giganitops destructor* Fab. of the Nectropical Region." The ants which I collected did not jump when they were disturbed but instead veered sharply toward the opposite side of the tree trunk.

Paratypes are to be deposited in The U. S. National Museum, the Museum of Comparative Zoology, at Harvard, and the collection of the author.

Affinities. *G. spatulatus* appears to be closely related to *kalshoveni* Wheeler, but it differs from *kalshoveni* in the following distinct characteristics of the major worker: In proportion to its length, the clypeus is much broader and is subhexagonal in shape; the head is more rectangular and possesses more sharply rounded posterior corners and a nearly posterior border; the thorax in profile appears more slender; the mesoepinotal impression is much broader; the posterior declivity of the epinotum is less steep; the petiolar node is much higher and larger, thicker above, less distinctly cuneate, and its superior border is less sharp; there is a darker body color, the mesonotum, episternum, and dorsum of gaster are brown, and there is a brown postocular crescent. Major workers of *spatulatus*, *kalshoveni*, and *chapmani* have clavate-spatulate hairs on the clypeus and upper surface of the mandibles.

G. spatulatus differs from *G. luzonensis* var. *chapmani* in the following characteristics of the major worker: The overall size is smaller; the thorax appears more slender in profile; the pronotum and mesonotum in profile are less convex; the mesoepinotal impression is deeper; the metanotum is less marked, not broader than long, and the mesometanotal suture is indistinct; the epinotum in profile is more angular; the petiolar node is higher, much thinner in profile, with a much thinner upper border, sharper corners, and a more deeply excized upper border; and there is a brown crescent above and behind the eyes.

The following key should serve to separate readily the major workers of five of the six known forms of *Gesomyrmex*:[3]

[3]Workers of the typical *luzonensis* Wheeler are apparently unknown.

1. Hairs on front and clypeus bifid or multifid at their tips.....**chaperi** André
   Hairs on front and clypeus not bifid or multifid at their tips; those on clypeus clavate with spatulate tips.....2
2. Petiolar node as thick above as below in profile, its superior border rounded and entire.....**howardi** Wheeler
   Petiolar node not as thick above as below, its superior border excized.....3
3. Mesonotum distinctly broader than long, very convex in profile, with anteriorly curved posterior suture.....**luzonensis** var. **chapmani** Wheeler
   Mesonotum not broader than long, much less convex in profile, with straight posterior suture.....4
4. Petiolar node about one and two-thirds times as broad as long, lower than the crest of the epinotum.....**kalshoveni** Wheeler
   Petiolar node longer than broad, as high as the crest of the epinotum, **spatulatus** n. sp.

I wish to express my appreciation to Dr. M. R. Smith who kindly presented me with references to the genus *Gesomyrmex* in the literature, to Dr. J. Bequaert who sent me for examination types of *G. kalshoveni* and *G. luzonensis* var. *chapmani*, and to Mr. J. W. Jones who checked and verified my description and drawings of *G. spatulatus*.

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THE BIOLOGY OF MICROVELIA CAPITATA GUERIN, 1857, IN THE PANAMA CANAL ZONE AND ITS ROLE AS A PREDATOR ON ANOPHELINE LARVAE[1]

(Veliidae: Hemiptera)

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INTRODUCTION

In the course of studies on malarial vectors in the Panama Canal Zone, attention was directed during the dry season to *Anopheles pseudopunctipennis pseudopunctipennis* Theobald. The dry season on the Pacific side of the Isthmus of Panama lasts from about the middle of December to the middle of April. During this period only a negligible rainfall occurs and the countryside becomes very dry with the streams either drying up completely or flowing at an extremely slow rate. For example, the Rio Cardenas, along the Chiva Chiva Trail, about four miles from Balboa Heights, was reduced to a trickle, and its sunny pools became covered with green algae. It was in the still sunny pools associated with the algae that *Anopheles pseudopunctipennis pseudopunctipennis* Theobald was found abundantly. In this same habitat, running over the surface of the water and algae were great numbers of the tiny veliid, *Microvelia capitata* Guerin. Their cast skins were to be seen everywhere on the water and algae. That the *Microvelia* were feeding upon the Anopheline larvae was strongly suggested by this association. A number of collecting trips were made during March, 1945, to collect these small Hemiptera and to study their feeding habits in the laboratory.

No records could be found in the literature of anopheline larvae having been utilized as food for *Microvelia* species. Bueno (1917) found that *Microvelia borealis* Bueno would feed upon daphnia in aquaria but fed them dead or waterlogged insects. Hungerford (1919:138) fed his reared specimens on plant lice and house flies. He added that they do very well if only ostracods and daphnia are in the water. Hoffmann (1924) successfully reared his species of *Microvelia* on a diet of cockroach nymphs thrown into the water upside down to expose the soft underparts. Jordan (1932), in rearing *Microvelia schneideri* Schltz., put crushed adult gnats, midges, and mosquitoes on the surface. For the larger instars he used crushed flies. He noted that the specimens in his aquarium would not accept *Podura aquatica*, which he found abundantly on the ponds where *Microvelia* was plentiful. As far as I know, the studies given below contain the first record of *Microvelia* species feeding upon anopheline larvae.

[1]This paper is a result of some studies of malarial vectors and their predators at the Army School of Malariology, Fort Clayton, Panama Canal Zone, during 1944 and 1945.

ACKNOWLEDGMENTS

I wish to take this opportunity to express my especial thanks to Mr. Philip Marucci, now with the Cranberry and Blueberry Laboratory, Pemberton, New Jersey, for the initiation of this study. His continued encouragement, optimism, and untiring efforts in assisting with the many problems that arose are sincerely appreciated. To Messrs. George S. Ryan and Wellman Turney I am very grateful for aid in the rearing work and in keeping records when I was not available. To my many associates, while in Panama, I am very grateful for their interest in the problem and I wish to thank them all: Dr. W. W. Middlekauff, now with the University of California, then in charge of the entomological investigations, for helpful advice in the preparation of this paper; Dr. Samuel L. Meyer, now with the University of Tennessee, for identification of the aquatic plants; and Messrs. Ross H. Arnett, Paul K. Adams, Robert Van Doran, George L. Wood, Joseph Griffing, and Robert Olson. I wish to thank Dr. Robert L. Usinger for encouragement in preparing this paper, and for reading the manuscript. His recognition of the scarcity of studies of this nature and of the lack of published records of *Microvelia* sp. feeding on anopheline larvae added impetus to the publication of this paper. I extend sincere thanks to Mr. A. P. McKinstry for identification of the species and to Dr. Edward S. Ross, of the California Academy of Sciences, for curating the material that was presented to the Academy in 1946.

EQUIPMENT AND METHODS

Although large numbers of *Microvelia* were collected and brought into the insectary in late March, 1945, it was not until April 12, 1945, that the first life history studies were begun in the insectary. The insectary was a screened-in portion of the ground floor of a barracks building. This arrangement allowed almost complete freedom of air movements and during rains accompanied by wind, the insectary floor was wet for eight feet in from the walls, and the air within the room was filled with fine droplets of moisture. These conditions so closely paralleled those of the out-of-doors that it appeared justifiable to correlate the life histories with meteorological data. Data taken at Balboa Heights, Canal Zone, (Marx, 1945), three miles from the laboratory and with about 100 feet difference in elevation, are used. The thunderstorms that occurred in the wet season covered both localities in almost all cases.

Breeding stock was kept in large, shallow, enameled pans about 15 inches by 10 inches in size. Although the alates showed some tendency to escape, few would leave if they were supplied with ample anopheline larvae to feed upon. Larvae of *Anopheles albimanus* Wied. were used exclusively for food, although from time to time small cockroaches and Collembola fell into the water and were attacked greedily. Larvae of *Aedes aegypti* L. were kept in each pan to cleanse the water. As these larvae hung at an angle of at least 45° from the surface, they could not be attacked by the *Microvelia*. When the *Aedes agypti* pupae were picked out each day, the alate *Microvelia* showed no tendency to fly away, but all ran rapidly to the farthest corners of the pans. Small squares of ordinary filing cards, bits of wood and bark, and leaves of

Pistia, *Naias*, *Salvinia*, and *Azolla* spp. were put in the pans. These were used for oviposition, as will be described later. However, the edges of the pans just below the surface of the water were most utilized for egg deposition.

For the individual life history studies, small vials 1 inch in diameter and 1¾ inches in height were used. These were kept about three-fourths full of water. A newly laid egg attached to a small piece of filing card was placed in a vial and the number of days required for the egg to hatch recorded. It was found that the small squares of paper aided the young insects to capture anopheline larvae, providing a place for orientation of the larvae other than the meniscus.

Every day larval counts were made. A few larvae died because of the rather pure water in the vials, but these were easily distinguished from those fed upon by *Microvelia*. The larvae which died naturally usually sank to the bottom, and if not, they were not shrunken in the slightest degree. Those fed upon were shrivelled, greatly shortened, and often twisted into an S-shape. To prevent natural dying in the vials, the larvae were changed at least every other day. Fresh larvae were substituted for those killed to assure a constant daily food supply.

Only first stage mosquito larvae were presented to all of the instars, except the first and second instars of the second, third, and fourth filial generations and to the second instar of the first generation. These smaller instars of *Microvelia*, it was rapidly learned, thrived best on what were termed "pinhead larvae", which were those freshly emerged. After a day or so, these grew larger and were then called "first stage anopheline larvae." It was found that about fifteen pinhead larvae would give the first instar bugs a better chance to find their prey. All the larger instars were supplied with eight first stage larvae daily. The adults were given second, third, and rarely, fourth stage larvae to feed upon.

When alate adults were kept, individually or paired, in the small vials, they had a definite tendency to fly out and escape. To avoid this, loose cotton plugs were used in the tops of the vials. These plugs probably increased the humidity in the vials and stopped the normal air currents. This more humid environment did not seem to increase the length of life of the alate adults, as the apterous individuals and pairs lived as long as did the combinations containing alates.

DISCUSSION

Copulation

The act of copulation has been adequately described by Bueno (1910) and so will not be repeated here. In eleven cases closely observed for thirty minutes after combining a male and a female, immediate copulation was noted in four, no copulation for at least thirty minutes in six, and one case where the male repeatedly attempted to copulate but was kicked off by the hind legs of the female. In those instances where copulation was delayed, the females varied in age from twenty-four to forty-eight hours, with one being eleven days old. Those females allowing immediate copulation were two, nine, nine, and fourteen days old.

The mating behavior of three pairs that copulated immediately was observed under a dissecting microscope for two and one-half hours in one case and about one hour in two cases. In the first instance the male was placed in the female's vial at 8:30 a.m. They copulated at 8:32 a.m., separating at 8:36 a.m. The male then followed her about closely, keeping his antennae straight forward and constantly jerking nervously. The female allowed the male to mount at 8:39 a.m. and to finish to 8:42 a.m. Although the female moved about the vial, the male continued to remain at her posterior, antennae straight forward, and once in a while let out a series of spasmodic jerks up and down, lasting approximately a second. They copulated again at 8:48 a.m., separating at 8:51 a.m. The male persistently followed her about, and copulation took place again at 9:22 a.m., with his backing off at 9:24 a.m. The last copulation observed took place from 10:28 a.m. to 10:30 a.m. The observations ended at 11 a.m.

The second pair copulated immediately at 9:54 a.m. and did not separate until 10:00 a.m. They repeated the act at 10:34 a.m. but lasted only one minute, again from 10:38 a.m. to 10:40 a.m., and from 10:47 a.m. to 10:49 a.m. The observations were terminated at 11 a.m.

The third pair mated at 10:01 a.m., fifteen seconds after discovering each other. This act required five minutes. At 10:08 a.m. the male attempted copulation, but the female escaped him by running up the side of the vial. He tried once more after she returned to the water surface, but she again ran up the side of the vial and the male fell off backwards. However, matings took place from 10:17 a.m. to 10:20 a.m., from 10:23 a.m. to 10:27 a.m., and from 10:47 a.m. to 10:49 a.m. Observations ceased at 11 a.m.

My movements at the microscope and my shutting off and turning on the light repeatedly seemed to have no effect on the activities of these copulating pairs, not even on the females who seemed to have little interest in the males at times. Those *Microvelia* not mating immediately ran about wildly in response to similar disturbances.

Oviposition

A survey of the literature shows varying reports as to where *Microvelia* lay their eggs, particularly whether just above or just below the surface of the water. Bueno (1910) found *M. americana* (Uhler) females deposited their eggs on the sides of the aquaria, just above the water surface, but not on the abundant duckweed furnished them. With *M. borealis*, Bueno (1917) found that the eggs were placed on the under surface of duckweed and if this was not available, they were deposited anywhere. In his study of *M. americana*, Hungerford (1919) reported that the eggs were placed as a rule just above the surface of the water on pebbles, jutting stones, and the like. Poisson (1924) was positive in stating the eggs of Veliidae were not immersed when placed on rocks and on aquatic plants, but verified many times that immersion of the eggs did not hinder the embryonic development. Of thirty-five eggs laid by a female of *M. schneideri* Schltz., Jordan (1932) noted that pieces of wood and reed and the floating fruit of *Rumex aquaticus* L. were preferred but gave no indication as to position. He also found that not all of the plants occurring in the natural environment of his *Microvelia* were equally used for egg deposition.

In the present studies, two types of egg-laying environment were provided: one, the confinement of the vials; and two, the broad, open pans. In the vials the females mostly laid their eggs on the edges of the vials just below the water surface, but probably from one-fourth to one-third of the total eggs laid were deposited on the edges of small squares of filing card provided for that purpose. The squares of card were often dispensed with and in such cases all of the eggs were laid on the edges of the vials. The eggs were deposited in an irregular manner. Even when laid in a group, which was unusual, the eggs were not placed

TABLE I

RESULTS OF DESSICATION TESTS ON *Microvelia* EGGS

Age before dessication, days	Total in each age group	Total showing development before treatment	Total emerging after dessication	Total not emerging	Time from laying to emergence,* days
Dessicated 24½ hours					
1	8	0	0	8	
2	4	0	0	4	
3	14	2	13	1	7, 8, and 9
4	9	9	9	0	7 and 8
5	9	9	9	0	7
Dessicated 29 hours					
1	3	0	0	3	
2	2	0	0	2	
3	9	5	6	3	8
4	1	1	1	0	8
5	8	8	8	0	8
6	6	4†	4	0	8
Dessicated 48 hours					
1	14	0	0	14	
2	3	0	0	3	
3	4	4	3	1	7, 8, and 9 (one each day)

*Time for untreated eggs, 6 to 7 days.

†Two had emerged just previous to dessication.

in any discernible pattern. Usually the eggs were scattered around the circumference of the vials, apparently having been deposited individually and at different times.

In all of the rearing records for the vials, only one female was found that laid an egg above the water line exposed to the air, and she placed only one egg on the edge of a vial. Six females deposited eggs free on the surface of the water and their respective totals follow: 1, 3, 2, 1, 2, 1.

The placing of eggs on dead anopheline larvae was more common, and eleven females were recorded as doing so. Their respective totals are: 10, 8, 4, 1, 3, 12, 8, 9, 8, 29, and 4. These eggs were laid along the sides of the larvae and always below the surface of the water. The remainder of the more than four thousand egg depositions observed in the vials were laid on the edges of the vials or on the card squares.

In the open pans small squares of filing cards, bits of wood and bark, dried leaves, and small plants of *Pistia stratiotes* L., *Salvinia natans*, *Azolla filiculoides*, and *Naias* sp. were placed on the surface of the water. Although no quantitative results were obtained, definite preference was shown for the dried leaves of the various plants and the card squares. The living leaves of *Naias*, *Pistia*, *Azolla*, and dried twigs came next in preference, while *Salvinia* and dried grass blades were almost unused for egg deposition. Only 5 of 381 eggs were deposited on the upper surfaces above the water line. Two of these eggs were on living *Pistia*, two on living *Azolla*, and one on a dried twig. Otherwise, the eggs were placed along the edges on the under sides of the leaves and twigs beneath the water surface. It was soon discovered that the majority of the eggs were laid around the edges of the pans just below the water surface. The level of the water went down due to evaporation, but more was added daily and the eggs were not harmed if exposed less than one day at a time. When all debris and plants were taken from the pans, the edges were used exclusively for egg laying, except for an occasional few on a dead anopheline larva floating at the surface.

Notes on air-dried eggs. To check the emergence of eggs exposed to the atmosphere, three tests were conducted which are reported in Table I.

From the results given, it appears that most eggs three or more days old before being subjected to dessication were able to survive and emerge. The younger eggs collapsed upon drying but regained their turgidity when re-wet. However, they always failed to develop. The time for embryonic development was lengthened somewhat by drying.

Two cases were observed, however, in which the squares of card bearing the eggs were pulled about one-half inch above the water line in the vials by cockroaches. These eggs were, in each case, dried for about twenty–four hours, two days after laying. Of the five so treated, all were fertile and hatched. The elapsed time from laying to emergence was six and seven days, the same length of time as for all other eggs kept moist.

That these latter five eggs hatched while others the same age did not, probably can be explained by the fact that the eggs mentioned in Table I were completely removed from any moisture or water surface and the card squares were dry when used to scrape the eggs from the edges of the vials. The latter five were just above the water in the vials where the air was supposedly nearly saturated and the card squares were waterlogged and took some hours to dry out. This suggests that complete air drying may be fatal to the more immature eggs, while they can withstand the normal humidity above a water surface, as would be the case in nature.

Oviposition patterns. Table II is a compilation of a number of records concerning oviposition and fertility of the adult females.

It will be noted that the females whose mating was delayed laid comparatively few eggs. The first eggs never appeared before the fourth

TABLE II

OVIPOSITION PATTERNS AND FERTILITY OF MATED AND UNMATED FEMALES

Age of Adults When Mated, Days		Infertile Eggs Laid Prior to Mating	Condition of First Eggs after Mating			Fertility Records		
♂	♀		Time following mating, days	Total laid	Fertility of first eggs	No. of eggs observed	Total infertile	Time over which eggs were laid, days
			First generation					
3*	0†	0	6	1	0	33	33	30
4	0	0	2	2	2	32	0	42
0	1	0	4	17	17	50	0	11
1	1	0	1	2	2	33	0	6
11	5	0	1	4	4	32	0	25
12	8	0	1	6	6	42	0	55
5	9	3	1	9	9	14	0	4
8	9	13	1	15	15	34	0	42
10	9	5	1	12	6	16	6	2
8	11	9	1	9	9	18	0	30
14	15	17	1	14	14	22	0	2
			Second generation					
0	0	0	3	4	3	101	5	62
2	0	0	2	2	2	165	6	73
1	1	0	1	2	2	61	2	27
3	2	0	1	2	1	91	4	31
			Third generation					
0	0	0	2	2	2	64	6	66
1	0	0	3	8	8	105	2	58
1	0	0	2	3	3	42	2	52
5	0	0	4	1	0	26	1	19
			5	5	5			
11	0	0	5	3	2	34	2	36
			Unmated females					
	0		4	1	0	184	184	37
	0		4	1	0	59	59	27

*The male died two days following combination.

†The 0 signifies the specimen was mated as soon as it became an adult.

or fifth days after emergence, and it seemed as though the females were holding back since their abdomens were greatly and continually swelled.

After mating, these same females tended to lay great numbers of eggs immediately, with a surprisingly large number fertile. The females that were mated as soon as it was discovered they were adults did not lay any eggs for a period of from two to five days. It is to be presumed that this period was needed in which to mature the eggs before any oviposition could take place.

The largest number laid in any one day is the 17 shown in Table II. Ten, eleven, or twelve eggs were common maxima recorded in the daily records, with greater totals being rare. The females showed a tendency towards periodicity in their laying. A gradual building up to the maximum would occur over a period of four, five, or six days during which period few eggs were laid each day. The females' abdomens would gradually swell during this interval until they actually bulged and then there would be a large number of eggs laid and the cycle repeated. The greatest number of eggs was produced during the first three-fourths of the females' life, with the dwindling of egg production heralding the approach of death.

Fertility notes. All the fertility figures in Table II are from daily lots of eggs scattered throughout the life of the mated females. These were observed carefully for emergence percentages. Fertility did not tend to drop as death approached, the infertile eggs being scattered throughout the lives of the females involved. It is not deemed significant that the infertile eggs were fewer in number in the first generation. For this generation, fewer records were kept and the chances of finding an isolated infertile egg were thereby reduced.

The fertility of the females ceased soon after the death of the males. The records are but four in number but indicate that fertility lasted at most four days—in one case only three—following death of the male. It is true that the females were near the end of their lives, but in seven out of eight cases in which the females died first, even the very last eggs laid were fertile. The exception involved five eggs laid the day a female died, of which two were infertile.

The first pair of adults recorded in Table II never produced any fertile eggs. The male died two days after confinement with the female. She was newly emerged and probably not ready for copulation. The male either died before the female allowed copulation, or if copulation did take place, the sperm were viable for only a short time. In accordance with this latter possibility, other paired adults were seen in copulation from time to time in the vials, indicating frequent copulation was necessary to maintain fertility.

Only two experiments were conducted to gain some idea of the fertility of eggs in relation to the length of time after copulation. The results are not reported in Table II but are given here. In one case, the female was two days old and the male six. They were mated for two hours and then separated for seven days, during which time the female laid twenty-five eggs. Twenty-one, laid throughout the seven days, were checked for fertility and all were fertile. Oddly enough, the day following permanent re-mating, eight days after the first mating, three eggs were laid of which two were infertile. In the second case, the female was two days old and the male six. Mating was allowed for two and one-half hours and then the male kept separately for eight days.

The female produced a total of twenty eggs. Twelve were watched carefully for fertility, some being taken from each day's laying, and all were found to be fertile. As in the above case, the day following remating, this female produced the same proportion of infertile eggs, eight out of twelve. Infrequent subsequent checks on the fertility of the eggs from these two females showed that they laid no additional infertile eggs. The results of these two tests were unexpected, and the author is unable to offer any explanation of the observed data.

Incubation Period

Various lengths of time for egg development have been recorded in the literature. Bueno (1910) reported 17 days for *M. americana* and (1917) 7 to 23 days for *M. borealis*, with 7 days for his controlled experiment of three specimens. Hoffmann (1925) found 18 days for *M. borealis* and 10 to 12 days for *M. buenoi* Drake. Hungerford (1919) found the time to be around 6 days in July for *M. borealis*.

In all cases, the incubation period for *M. capitata*, regardless of season, was from 6 to 7 days. As the temperature was rather constant throughout this study, it is believed that the temperature of the water had quite an effect upon the embryonic development. Temperature differences may account for the different incubation periods reported above.

Emergence

Three observations on emergence from the egg were recorded, two in which the eggs were submerged and one with the egg at the water surface. Although looked for under a binocular microscope no post-natal molt was seen. Bueno (1917) did not find this "amnion" but Hungerford (1919:38) definitely did. It could be missed very easily, as Hungerford pointed out that the membrane has to break before the antennae, legs, and beak are free. In the notes given below, it appears as though the molted membrane remained in the egg, and that probably accounts for its not being seen.

The first emergence began at 9:28 a.m. The body was pale yellow, the eyes red, and the appendages white with the joints black as the bug pulled free from the egg. The egg was submerged, and when the nymph touched the surface with its leg, the whole body broke through and it lay flat on the surface. At 9:30 a.m. the legs were strong enough to support the body above the surface. The tiny bug rested for three minutes and then began to rub all the appendages against each other and against the body. At 9:41 a.m. the body was darker and at 10:00 a.m. when the observations terminated, the body was blackish-gray and the legs gray.

The second emergence began at 3:22 p.m., the whole colored mass moving slowly downward from the egg. It looked as if the whole egg were moving. After the insect was completely free from the egg case, the antennae, followed by the legs, spread, opened out, and become functional. This egg was just at the water surface, and the tiny bug at no time touched the water before its legs were functional. No post-emergence molt was noted, even though it might appear that the membrane was shed outside the egg and above the water surface. The bug rested until 3:40 p.m., occasionally moving an appendage slowly.

TABLE III

Daily Rainfall at Balboa Heights Correlated with Life History Studies

April, 1945

Day of the month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	
Number of life histories started (emergence from egg)												9	3	1		9		23	8	1	2		3	2							
Number attaining adulthood																															
Daily rainfall in inches	—	—	—	—	—	T	—	—	—	—	—	—	—	T	.01	—	12	—	—	—	—	—	T	11	—	1.02	.18	T	—	.40	
Number of *Microvelia* dead each day																	1						5	4	4	4	1		1		
Instars of those dead (1=first, 2=second, etc.)																	1						2 3	1 2	2	2 3	2		3		

May, 1945

Day of the month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Number of life histories started (emergence from egg)											2	7		15	8	7	3	1	7	1	1										
Number attaining adulthood	5	5	2	5	5	3	6	6	5																					1	1
Daily rainfall in inches	.07	.64	—	1.07	.06	—	—	—	—	.10	.78	.15	—	T	—	—	.01	—	.02	—	—	.02	—	—	—	.44	.08	.07	.09	—	.62
Number of *Microvelia* dead each day			1		1	2	1							2	1	3	1	3	1		2		1		1	2					
Instars of those dead (1=first, 2=second, etc.)			4		5	A† A	5							1	1	1	1	1 2	1		1 2		2		2	2					

†Second and third days of adult life.

June, 1945

Day of the month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Number of life histories started (emergence from egg)									2	2	4	2	3	1		1			4		2					2	1		2	1
Number attaining adulthood	3	15	9	6																			1		1	1	2			
Daily rainfall in inches	1.58	T	.83	—	.01	.04	1.42	T	.36	.04	—	.03	.04	—	—	—	.08	—	.04	.01	.11	.04	.08	—	.06	.20	.19	.01	T	—
Number of *Microvelia* dead each day						1									1	1				2	2			3		2		1	1	
Instars of those dead (1=first, 2=second, etc.)						5									1	1				3 5	2 4			1 2 4		3		5	3	

July, 1945

Day of the month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Number of life histories started (emergence from egg)	1	3	1	2	3		1		8	2		4			1	1	4	1		3	1	2	1	1	1	1			3	1	
Number attaining adulthood		1									2				2	1		1	1	1			1	1	2	1			1	1	2
Daily rainfall in inches	—	.30	.02	1.11	.04	—	.47	—	.11	T	—	.44	.10	.08	—	—	.17	.34	.01	.01	.04	T	.19	.12	—	.22	1.32	.15	—	—	.65
Number of *Microvelia* dead each day			2			1			2		1		1	1			2			2	2	2				2	1				
Instars of those dead (1=first, 2=second, etc.)			3 5			3			2 3		3		1	5			1 3			3 5	3 5	4 5				1 4	3				

August, 1945

Day of the month	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Number of life histories started (emergence from egg)																															
Number attaining adulthood	1		1	1		1		1	1	1		2																			
Daily rainfall in inches	.02	.63	.30	.04	—	.03	.01	T	—	.31	.70	.01	.11	.64	.35	.03	.35	.06	—	.03	.14	—	.04	.25	.07	.28	1.36	.54	T	—	.07
Number of *Microvelia* dead each day								2			1																				
Instars of those dead (1=first, 2=second, etc.)								3			5																				

The last emergence began at 2:10 p.m. The insect pushed its way out of a long slit in the egg by enlarging and contracting the body. It was all out of the egg after a final swelling and rested at 2:12 p.m. At 2:13 p.m. the appendages came free from the egg and the bug rested again until 2:18 p.m. At this time, it began to pull itself free from the water and to break out of the surface film. The insect would rest and struggle alternately. The antennae were freed first and then the front and middle legs, following which the head was lowered almost to the water and the abdomen raised. From this position, the hind legs were pulled free of the water and dried. The insect was completely through the surface film at 2:20½ p.m., after which it cleaned the appendages by rubbing them against each other until 2:22 p.m. One hind leg was actually put as far forward as the eye during the cleaning. At 2:22 p.m. the insect began to run about actively.

Sometimes when transferring eggs from the sides of a vial to a card square, the eggs would not stick to the card and would sink to the bottom of the vial. Of 29 eggs watched on the bottom, all emerged, although they had sunk not over 24 hours after oviposition. The exact time of hatching was unknown, but not over 24 hours elapsed in any case before they were observed after hatching. Eighteen tiny *Microvelia* were found walking about on the bottom or sides of the vials. One was definitely known to reach the surface, but none seemed to exhibit any negative geotropism and climbed straight up the walls of the vials. Eleven of the tiny insects had drowned and were lying dead upon the bottom.

Postembryonic Development

The developmental periods recorded in the literature vary in duration. Bueno (1910) gives from 22 to 31 days for *M. americana* and (1917) from 15 to 49 days for *M. borealis*. Other records include the following: Hoffmann (1925), 22 to 27 days for *M. borealis* and 26 to 37 days for *M. buenoi*; Jordan (1932), 33 days for *M. schneideri*; and Poisson (1924), 23 days as the average time for *M. pygmea* Duf. All of these records appear to be from *Microvelia* reared under artificial conditions.

Hoffmann (1925) pointed out that, "Inasmuch as temperature plays such an important role in the development of these forms, the rate of development at unknown temperatures is not extremely valuable." As was mentioned in the introduction to this paper, the laboratory conditions under which the present life history studies were carried out so closely paralleled those of the natural environment that some conclusions appear justified, and these follow.

Correlation with climatic data. Daily rainfall totals for the months of April, May, June, July, and August are shown in Table III while monthly averages of temperature, temperature range, and evaporation for these same months are given in Table IV. These data (Marx, 1945) are for Balboa Heights, Panama Canal Zone, three miles from the laboratory.

TABLE IV

METEOROLOGICAL DATA OF BALBOA HEIGHTS, MONTHLY AVERAGES

Month	April	May	June	July	August
Mean temperature, degrees F.	85.4	81.5	83.6	80.3	81.4
Maximum temperature, degrees F.	95.0	92.0	93.0	92.0	91.0
Minimum temperature, degrees, F.	73.0	73.0	74.0	73.0	73.0
Daily mean range, degrees F.	17.2	12.6	12.1	12.6	12.0
Total rainfall, inches	1.84	4.22	5.17	5.89	6.37
Evaporation, inches	5.431	3.451	2.468	2.386	2.358

These tables also show the starting dates of each life history, and the day and instar that each specimen died or grew to an adult. Sixteen first stage nymphs died, 14 seconds, 15 thirds, 5 fourths, 11 fifths; and 2 adults died two days after the last molt. Although the smaller instars appeared to be more susceptible to adverse conditions, enough of the larger ones died to make it appear as if humidity had some effect upon the death rate.

A check of daily rainfall totals with the number of deaths seemed to indicate some correlation between these two phenomena. It may be noted here that the thunderstorms passed over from noon to later in the day, while most of the observations were made during the mornings. This would account for deaths occurring on the same day as heavy rains. During April, deaths fell off following the heavy rain of the 26th. In May, deaths did not decrease after the rain of the 4th but were otherwise most numerous during the dry mid-month period, a rain of 0.44 inch appearing to halt further deaths while rains on May 31, June 1, and June 3 continued to halt dying. The only other heavy rain, on June 7, seemed to have a lasting effect, although there was some break between generations at that time. The records for July and early August tend to show the same trend. Nothing positive is indicated by these data, but it is suggested that the *Microvelia* may not be able to withstand dry conditions as well as humid conditions.

Temperature probably entered in here also, and it is to be regretted that no daily temperature records could be obtained. However, the temperatures were quite constant, except for April, which was noticeably hotter, and for June, which may account for the great number of nymphs dying in the latter month. Air humidity, as shown by the evaporation of water in inches, was rather constant for the wet months. April's figure was very high as a result not only of lack of rainfall but also of the strong dry north winds that blew so regularly in the dry season. These winds subsided in early May and there was little air movement during the wet months of June, July, and August.

Table V gives a summary of the average length in days of all stages in the life history.

TABLE V

RESULTS OF LIFE HISTORY STUDIES BY GENERATIONS

GENERATION	MONTHS	AVERAGE DURATION OF EACH STAGE						TOTAL DEVELOPMENTAL PERIOD
		Egg Stage, days	First Instar, days	Second Instar, days	Third Instar, days	Fourth Instar, days	Fifth Instar, days	Average number of days
First.....	April–May	6.5	5.1	4.9	3.2	3.2	3.7	26.6
Second.....	May–June	6.5	5.6	3.1	2.7	2.8	3.5	24.2
Third.....	June–July	6.5	2.5	2.5	2.9	3.0	3.3	20.7
Fourth.....	July–Aug.	6.5	2.2	2.2	2.7	3.1	3.7	20.4

The average number of samples used for any instar of each generation was 28, while the minimum was 16 and the maximum 41. The duration of the egg stage remained constant throughout. During April and May, the drier period, the life histories required more time with the first and second stadia showing the greatest increase in duration. The last two generations taking place during rainy months are approximately equal in duration. It is believed that the differences in rate of development are a result of the various climatic conditions encountered. The first generation took place under a hot, dry, and windy environment; the second, during a transition period between the two extremes, while the third and fourth took place during the slightly cooler, humid, and nearly windless period.

Feeding records. The number of anopheline larvae fed upon by the various nymphal stages is summarized in Table VI.

TABLE VI

NUMBER OF ANOPHELINE LARVAE UTILIZED FOR FOOD DURING THE DEVELOPMENTAL PERIOD

GENERATION	AVERAGE NUMBER OF ANOPHELINE LARVAE FED UPON BY EACH INSTAR				
	First Instar	Second Instar	Third Instar	Fourth Instar	Fifth Instar
First.....	9 1st instar	14 pinhead	14 1st instar	14 1st instar	16 1st instar
Second.....	15 pinhead	16 "	15 " "	16 " "	17 " "
Third.....	14 "	20 "	15 " "	13 " "	15 " "
Fourth.....	20 "	19 "	15 " "	15 " "	17 " "

The tiny pinhead larvae proved to be more of the size required by the small first and second stage nymphs, although the first stage nymphs of the first generation were able to capture and kill large first stage anopheline larvae.

The appearance of the attacked anopheline larvae is given in the introduction. However, some larvae were fed upon to a greater degree than others, and some *Microvelia* had a tendency to feed a little upon one larva, and leave it to search for another before finishing the first. In

this way, large numbers of larvae were killed, but their contents were not completely consumed.

It was found, in making up this summary, that if a nymph fed a great deal as one instar, it would take less food as the next, and vice versa. The majority of the totals of larvae fed upon in each instance tended to be close to the averages, while extreme deviations were few in number.

Life histories with only four instars. The number of nymphal instars has been known to vary since 1917 when Bueno found only four for apterous forms of *M. borealis*. Hungerford (1919.139), working with *M. borealis*, usually found four but noted that there were five in some. He suggested that the difference might be due to variation or to the apterous forms having fewer stages than the winged. Five species are known to have five instars, even in the apterous condition. These are *M. americana* (Bueno, 1910), *M. pygmea* (Poisson, 1924), *M. schneideri* (Jordon, 1932), *M. hinei* Drake and *M. albonotata* Champion (Hoffmann, 1925). Hoffmann repeated Bueno's work with *M. borealis* and confirmed the presence of four instars. This same author found only four nymphal stages in *M. buenoi* also. He found the number of instars constant throughout his studies.

In the present study, 110 life histories were reared from egg to adult in the four generations, of which 76 were apterous. The sexes were about equally divided throughout. Only 9 of the apterous forms had four nymphal instars, and 8 of these were male. Table VII gives a summary of the duration of the stadia.

TABLE VII

LIFE HISTORIES OF MICROVELIA HAVING ONLY FOUR NYMPHAL INSTARS

GENERATION	SEX OF SPECIMEN	AVERAGE DURATION OF EACH INSTAR				TIME FROM EMERGENCE TO ADULT, days
		First Instar, days	Second Instar, days	Third Instar, days	Fourth Instar, days	
Second*.....	♂	4	4	3	3	14
	♂	3	5	3	3	14
Third†.....	♂	3	2	5	4	14
	♂	5	3	6	4	18
	♂	3	3	2	6	14
	♂	3	2	5	3	13
Fourth‡.....	♀	7	2	2	3	14
	♂	5	2	2	5	14
	♂	3	3	2	6	14

*The second generation had a post-embryonic period of 17.8 days for those with 5 instars.

†The third generation's period was 14.2 days.

‡The fourth generation's period was 13.9 days.

The length of the life histories was rather close to that of the over-all average, the exception being the second generation, where those with four instars completed their development in almost four days less than the average. Comparing the length of each stage with the averages given in Table V, we find some of the stadia here to be of slightly longer duration to make up for the lack of one complete stage.

TABLE VIII

LENGTH OF LIFE, FECUNDITY, AND FEEDING DATA OF MICROVELIA ADULTS

SEX OF SPECIMEN	TIME LIVED, DAYS	TOTAL EGGS LAID AFTER MATED	EGG-LAYING PERIOD IN DAYS	AVERAGE NUMBER OF EGGS PER DAY	TOTAL ANOPHELINE LARVAE KILLED AND FED UPON, BY INSTARS			
					First	Second	Third	Fourth
First generation								
Alate male	44					89	38	
Apterous female	44	237	33	7.2		96	32	
Apterous male	67					Incomplete		
Alate female	73	324	65	5.0		61	111	
Alate male	53				111		52	
Apterous female	54	253	46	5.5	114		52	
Alate male	82					126	104	
Apterous female	79	283	76	3.7		101	104	
Alate male	82					121	116	
Apterous female	46	179	37	4.8		119	29	
Apterous male	52					Incomplete		
Alate female	36	139	25	5.6		110		
Alate male	86				150		134	
Apterous female	72	376	70	5.4	128		95	
Alate male	46					109	18	
Apterous female	49	226	44	5.1		94	35	
Second generation								
Alate male	93					207		
Apterous female	75	505	74	6.8		177		
Alate male	64					163		
Alate female	64	392	63	4.6		163		
Apterous male	60					160		
Alate female	35	195	33	5.9		90		
Apterous male	43					102		
Apterous female	32	173	31	5.6		73		
Third generation								
Apterous male	51						126	
Apterous female	44	163	40	4.1			98	
Apterous male	63						143	
Apterous female	63	434	62	7.0			138	
Apterous male	71						89	
Apterous female	68	242	67	3.6			89	
Apterous male	57						87	
Apterous female	62	427	55	7.8			100	
Apterous male	46					12	86	
Apterous female	53	187	41	4.6			109	
Unmated specimens								
Apterous female	41†	184	37	4.9			118	
Apterous female	31	59	27	2.2			87	
Apterous male	72							119
Apterous male	67							116

†Escaped.

It may be noted that no individual appeared in the first generation with only four stages. Just why this should be is not clear. If the confinement of the small vials had any effect upon the number of stages, why did not those with only four appear in the first generation? This phenomenon as presented here does not answer Hungerford's suggestions, although the variation is apparently restricted to the apterous forms and almost entirely to the male sex.

Activities of the Adults

Length of life. Bueno (1910) and Jordan (1932) have reported the adults as the overwintering stage in America and Europe, respectively. Bueno kept a female in his aquarium from October 2, when it emerged, to its death on December 31, and two males from October 2 into January. In the author's studies, only one male lived as long as Bueno's female—93 days—while most of the adults lived a shorter period, as shown in Table VIII.

It is very probable that Bueno's and the author's figures represent approximately the maximum duration of adult life under warm conditions. Both under artificial conditions and in the tropics, there would be no necessity for a long hibernation period during the winter.

It was often noted that the mated adults would die within three to seven days of one another. This does not show clearly in the table, as very often one individual was kept singly for a time before mating. In only two cases did both individuals die on the same day.

The egg totals given in Table VIII are those laid during mated life and do not include the scattered few that might have been laid prior to mating. The total number of days during which the eggs were laid includes only the days from pairing until death of either partner. As was discussed under "Oviposition," the egg production tended to decrease somewhat as the females grew older. The average number of eggs per day showed some variation, some fertile females being significantly lower in production than one of the unmated females. The unmated female that escaped possibly did so before age cut down on her daily laying totals. The other unmated female produced very few eggs and her record is more like those of the females before they were mated (see Table II). However, egg production does not appear to be associated entirely with reproductive activity. The unmated females seemed to be inhibited in egg laying, depositing comparatively few eggs, while their abdomens remained greatly distented.

Of the 17 females listed in Table VIII, seven died with their abdomens greatly swollen, probably due to eggs that never were laid. Four died with their abdomens quite swollen, five moderately swollen, and one not swollen at all. Usually the condition of the abdomen remained unchanged for a period of three to six days prior to death. It appeared that some females could not lay the last eggs contained within them.

Feeding records. The feeding records in Table VIII include the total anopheline larvae fed upon throughout the individuals' lives, whether mated or not. The total number of larvae utilized for food by the mated pairs was divided in half, and each half considered as killed by each adult. As pointed out earlier, the degree to which the larvae were sucked dry of their body fluids varied greatly, but most larvae were badly shrunken and only a few hardly fed upon. In each case where

larvae of more than one instar were presented, the total number of larvae fed upon by an individaul is a combination of the instar totals in the table. Of the individuals fed larvae of only one instar, the averages are 3.0 second stage larvae per adult per day, 2.0 third stage, and 1.7 fourth stage.

Miscellaneous feeding notes

Upon anopheline larvae. It was often observed that when an anopheline larva rose to the surface and disturbed the surface film beneath a *Microvelia*, the *Microvelia* would immediately react and explore the movement with its proboscis. Often when touched, the larvae would wriggle to the bottom. It was thought that the bugs were more startled than hungry in these cases.

Only one case was observed in which a larva was attacked and fed upon from the beginning. The *Microvelia* stood over the fourth instar larva and jammed her beak into it at the sixth abdominal segment. She held the integument firmly with the tip of the beak and with the stylets fed on the internal juices. The larva was not lifted from the water at any time. The beak was bent readily at the membrane between the second and third segments as she fed. The stylets could be, and were, extended for a distance slightly exceeding the anterior tibiae in length from the end of the proboscis. The stylets kept up a continuous searching and whipping action, searching here and there within the body for liquids. The larva was shrunken lengthwise upon the extraction of body fluids. The stylets were exceedingly flexible and were capable of being curved into a complete loop, which was observed twice. The male kept bothering the female during this period, trying to get some food, too, but she kept moving her posterior end towards him and kept moving away also.

Only one other observation was made while a *Microvelia* fed and this was a first instar nymph with a first stage anopheline larva speared on the end of its proboscis. The proboscis was held straight out in front of the head with the larva clear above the water.

Upon other insects. During the dry season, six Collembola were found in the vials with their contents sucked out. Probably these Collembola were attracted to the water in the vials and were attacked immediately upon reaching it.

Two first instar cockroaches, *Periplaneta americana* L., fell into separate vials and each was sucked dry of its body fluids. The *Microvelia* were second and fourth instars, respectively. Numerous cockroaches of the smaller instars were thrown into the breeding pans. The *Microvelia* would keep at a safe distance until the cockroaches were drowned and then congregate around the bodies seeking to suck out the body fluids.

Upon Microvelia eggs. In only two instances were females found sucking the fluid contents from their own eggs, one with a partially developed embryo in it. The eggs were not lifted out in front of the body, but were kept on the water surface. There was no evidence found that this was a usual practice as the eggs not removed from the vials would develop normally and those that did not never appeared emptied of their contents. Possibly more eggs would have been utilized for food if the adults had not been so well fed.

Upon immature Microvelia. Of all the 202 eggs that hatched in

seven vials with seven pairs of adults, no nymph was ever attacked and fed upon by the adults. A single record of an adult, a male, feeding upon a first instar nymph occurred during the open-pan experiment (see below). The adults were probably hungry from a scarce food supply and the nymphs were six days old, presumably without food, and so were weakened, if not near death. How many young would be killed for food by the adults under natural conditions is unknown, but it appears that well-fed adults have no interest in their young as a food source.

Upon other Microvelia adults. Adults did not seem to be able to attack and kill other adults. Only in a single case was an adult attempting to pierce the integument of his recently dead mate. He approached the carcass, put his proboscis straight out in front, and attempted to pierce it. When unsuccessful, he tried successively different places, but never with any success. The integument always seemed to be too tough. Even when four or five adults were crowded into a small vial for a week or two, none was ever killed.

Upon anopheline eggs. Two fifth instar *Microvelia*, one of each sex, were placed in a vial with 27 *Anopheles albimanus* eggs. After two days, two eggs hatched and one larva was fed upon. The eggs were thereupon changed and 55 added. The next day seven had hatched and the seven larvae were fed upon by the *Microvelia*. These were removed and fresh eggs substituted. The male died after six days, not molting. Following this, the eggs were changed daily to prevent hatching. The female died after eleven days of such treatment, still in the fifth stage. Anopheline eggs definitely did not seem to be utilized at all for food, possibly because the *Microvelia* did not readily recognize food that was not active.

Feeding in a large, open pan. To test if *Microvelia* could find and capture anopheline larvae in broad expanses of water as well as in the little vials, a pan with a water surface of 8 by 12 inches was used. Two apterous adults were employed and six fourth instar larvae were provided. Every day the number of dead larvae was checked, the larvae were removed and enough added always to keep six in the pan. The two adults killed and fed upon ten fourth stage larvae and one pupa in the 14 days this experiment was continued, a total far below those recorded for adults with ample food supplies in the vials. During this period, numerous eggs were laid and 20 nymphs emerged before closing the experiment. None of the nymphs, which hatched six days before the termination, was seen feeding, although they could have fed upon the larval remains discarded by the adults. It was concluded that *Microvelia* can track down, find, and kill larvae over a large water surface. These results led me to believe that anopheline larvae form a natural food for *Microvelia capitata* in its native habitat.

Wing Development

Bueno (1910) mentioned that the phenomenon of aptery is displayed in a very marked degree by *M. americana*, but that it was possible to find a few winged individuals in sheltered spots, under overhanging banks, or in exceptional seasons or situations. He added that in the tropics winged individuals were more abundant, adding that Hope had found almost all winged forms of *M. pulchella* Westwood on the Island

of St. Vincent. In his life-history study of *M. borealis*, Bueno (1917) made no mention of alate forms, while Hungerford (1919:137) stated that he found this same species in Kansas in both the apterous and winged state. In Plate XII, Hungerford figured apterous and alate forms of both sexes. He made no statement concerning the relative abundance of each form. Hoffmann (1925) was convinced that Hungerford reared *M. hinei* rather than *M. borealis*.

Jordan (1932) found that winged forms occurred in *M. schneideri*, but that all of the progeny of one alate and one apterous parent always gave apterous progeny. He stated that this result was the same as that obtained in rearing *Hydrometra* and *Mesovelia*.

Poisson (1924) found the apterous form of *M. pygmea* to be more common in the Norman region. Attempting to find reasons for the two forms, he found that the apterous form appeared "pure" and that the development of the wings was an hereditary character (p. 297) and added (transl.), "The direct action of the factors of nourishment and temperature do not appear to enter into action as 'determinants' of wing polymorphism." He even went so far as to suggest that the apterous form probably had the value of a "new-born" species (p. 272), based upon the fact that the genital segments were larger in the apterous forms than in the alates. However, he could find no size or other variations in the copulating organs of the two forms. Poisson had not verified experimentally if the crossing of the two forms was possible (p. 270) but based his conclusions on the facts he observed in the Gerridae and Hydrometridae. He added, "One is led to suppose that the non-mixing could be total between the two forms of *M. pygmea*." Lending weight to his conclusion, he added that he never found an alate in a locality of apterous forms.

The results found for *M. capitata* do not seem to bear out Poisson's conclusions. The intermingling of alate and apterous forms was so complete that his ideas of two species arising from the two forms is not considered applicable here at all. When brought into the laboratory, slightly more than one-half of the adults were alate. This nearly fifty-fifty ratio was maintained for eight months in the open pans, from the height of the dry season into the wettest months. The *Microvelia* were not exposed to direct rain, but did receive a fine mist during thunder storms.

In contrast to that ratio, Table IX shows how wing development receded with each successive generation, except the last.

TABLE IX

WING DEVELOPMENT BY GENERATIONS WITH SPECIMENS REARED INDIVIDUALLY IN SMALL VIALS

GENERATION	WING PATTERN OF ADULTS AND FIFTH STAGE NYMPHS, TOTAL IN EACH GROUP			
	Alate Male	Apterous Male	Alate Female	Apterous Female
First	14	9	15	16
Second	8	13	2	14
Third	0	17	1	9
Fourth	3	8	0	7

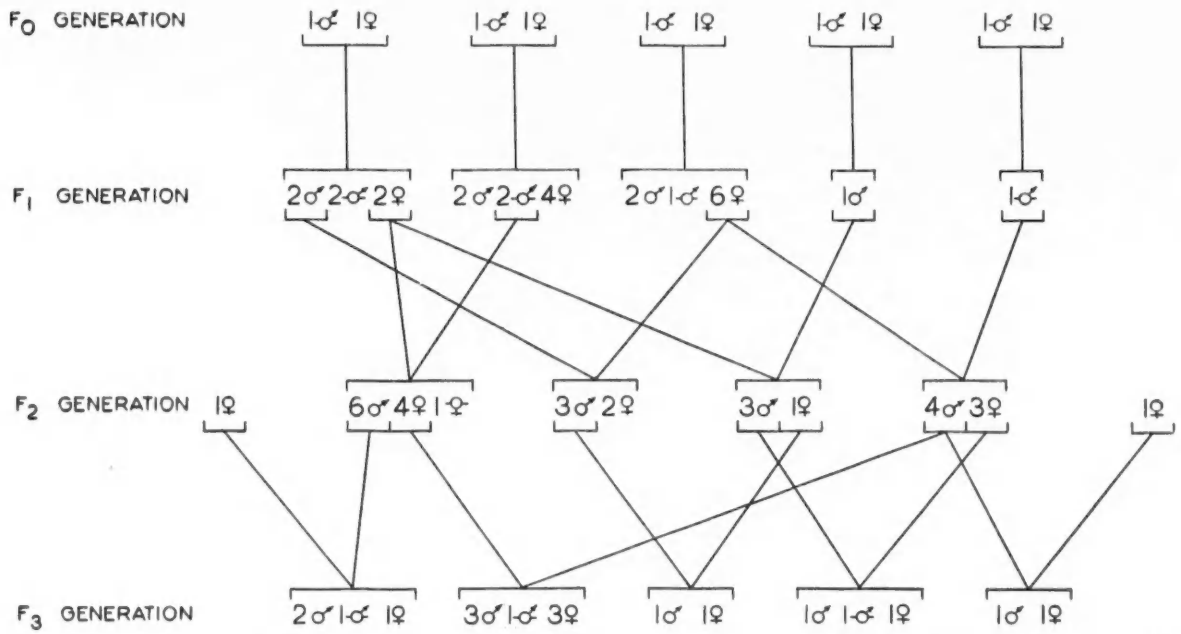

FIG. 1. Wing development within the filial generations. Each line represents a particular individual chosen for a parent for the next generation from the box at the upper end of each line.

The first generation shows a few more alates, and probably represents the proportions of those forms to the total when brought in from the field. The totals are the combined records of adults and fifth-stage nymphs that did not become adults but whose sex and condition could be easily told.

Figure 1 gives the wing development of the filial generations only. Beginning with five mixed pairs, aptery continued to increase until the F_3 generation, when three alate males appeared as progeny of apterous parents. It may be noted that the only alate form to appear in the F_2 generation was from alate parents, which may or may not be genetically significant. Due to a large number of deaths occurring towards the end of the third generation, it was necessary to introduce two females from the breeding pans to increase the total number of mated pairs. The progeny of these two females probably should not be considered. However, those progeny do not change the ratio of alates to apterous forms when included in the total.

Two possible reasons for the increase in aptery suggest themselves. One is the confinement provided by the vials. In enclosed situations, the *Microvelia* possibly encounter some factor that inhibits wing development. On the other hand, crowded quarters might make for wing development so that the specimens could leave the confined environment.

The other reason involves the over-feeding of the developing stages. With an bundance of food always at hand, it is possible that wings are not necessary to carry the individuals to a more provident environment. Therefore, wing development may lag in the presence of ample food. That food may not be the deciding factor is given impetus by the fact that the *Microvelia* in the breeding pans were provided with large numbers of anopheline larvae daily, not to mention such cockroaches, flies, etc., that fell into or were thrown into the pans. As mentioned above, the alate forms comprised at least one-half of the total in the pans throughout the experiment.

SUMMARY

The semiaquatic veliid, *Microvelia capitata* Guerin, was found abundantly during the dry season in sunny drying streams in the Panama Canal Zone. In the same association, larvae of *Anopheles pseudopunctipennis pseudopunctipennis* Theob. were plentiful, suggesting that the predatory *Microvelia* fed upon the larvae. Subsequent laboratory studies showed *Microvelia capitata* to be an active predator upon anopheline larvae and four generations were successfully reared using only anopheline larvae for food. Other food was greedily accepted and included immature cockroaches and Collembola.

Life history records were kept daily through four generations, extending from the middle of April, in the dry season, to the middle of August, well into the wet season. The duration of the egg stage varied from six to seven days, regardless of season. The postembryonic period, with five nymphal stages, varied with the seasons, requiring an average of 20.1 days in the dry season, 17.7 days during the transition period, and 14.2 and 13.9 days for the two generations in the wet season. The temperature was highest for the first generation and the humidity much lower. These two factors seemed to be responsible for the

increased duration of the first two generations. The first two nymphal instars in particular and the third to a slight extent were lengthened by the warm, dry conditions. Of 110 complete life histories, 76 were apterous. Eight apterous males and one apterous female had only four nymphal stages. The duration of these four-stage life histories averaged 16.5 days.

The *Microvelia* were fed larvae of *Anopheles albimanus* Wied. Tiny freshly emerged "pinhead" larvae were given the first and second stage nymphs, and large first-stage larvae to the third, fourth, and fifth stage nymphs. The first stage averaged 16 pinhead larvae each, the second stage 17, the third stage averaged 15 first-stage larvae each, the fourth stage fourteen and one–half, and the fifth 16. Anopheline larvae seemed to constitute a natural food source.

Thirty–seven adults, seventeen mated pairs and three single specimens, were fed until they died naturally. The maximum length of life for the males was 93 days and 79 for the females, while the minimum was 43 for the males and 31 for the females. The majority averaged from 50 to 80 days. The adults fed upon large numbers of anopheline larvae. Many of the adults were given larvae of more than one instar throughout their lives, but there are some records in which the adults fed exclusively upon one instar. These averages per day per adult are 3.0 second stage anopheline larvae, 2.0 third, and 1.7 fourth. The egg production records were kept for each female. The average for mated females varied from 3.6 to 7.2 eggs per day and from 1.1 to 4.9 for the unmated females. The maximum number of eggs laid by a mated female was 505 and the minimum 139. Fertility of the mated females was high and the percentage of infertile eggs varied from 0.02% to 0.09% throughout the length of their mated lives. A minimum of two days was required before freshly emerged females produced any eggs. Only infertile eggs were produced four days following the death of the male. Unmated females seemed to be inhibited in egg laying, but upon mating, would deposit large numbers of eggs, up to 17, within 24 hours of copulation. In nearly all cases, all of these eggs were fertile.

Eggs were deposited primarily along the sides of the pans or jars containing the females. Floating pieces of cards, dead anopheline larvae, pieces of wood, bark, and dead and living leaves of various water plants were utilized. Of over 4,300 eggs, only 6 were deposited above the water surface, the remainder being placed just below the water surface, regardless of the medium upon which they were laid. Some eggs were air-dried for periods varying from 24 and one–half to 48 hours. In all cases, eggs less than three days old failed to develop, while a portion of those three days old did not. All of the eggs four, five, and six days old emerged but the embryonic period was extended to seven, eight, and nine days. Eggs only partially air-dried, and above a water surface, completed their development normally and in the usual time of six to seven days. Complete air-drying was fatal to the more immature eggs.

Observations on the number of acts of copulation of previously unmated adults revealed that five were made in a period of two and one–half hours and four each in two periods of one hour each. The acts lasted from one to six minutes, with a three-minute average.

Observations on the feeding of *Microvelia* adults in confined vials revealed that they fed in only two instances upon *Microvelia* eggs and in none upon the nymphs that emerged in the vials. In a large pan, with only six anopheline larvae present, the male did attack a first-stage nymph. It was concluded that when well fed, the adults do not feed regularly upon their own eggs and young. The adults were unable to pierce the integument of other adults with their mouth parts, so could not feed upon them. *Microvelia* did not feed upon anopheline eggs in a starvation test. The adults of *Microvelia* were able to find, attack, and feed upon anopheline larvae in an open pan, when only six larvae were present in an area of two-thirds of a square foot.

Wing development was correlated with the confined area of the vials. The specimens brought in from the field were about one-half alate and one-half apterous. This ratio was maintained in the broad breeding pans throughout the six months the experiment was conducted. In contrast, the second generation had only 27% alates, the third 3.7%, and the fourth 16%. Of the filial generations, the percentages of alates were 33%, 3.7%, and 16%. In the F_3 generation, three alate males appeared as progeny of apterous parents, so aptery did not breed "pure." The possibility of the confined area being responsible for the increase in aptery is strongly suggested. Over-abundant food supply and the change of seasons are not considered as major factors, as the proportion of alate forms remained the same in the open breeding pans.

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NEW SPECIES OF CRANE-FLIES FROM SOUTH AMERICA. PART XIII[1]

(Diptera: Tipulidae)

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The novelties discussed herewith are all from Peru and Ecuador, particularly from the former where they were collected in the Departments of Loreto and Huanuco, mostly by my friends Messrs. José M. Schunke and Felix Woytkowski. The types of the novelties are preserved in my large collection of these flies. All species fall in the great tribe Eriopterini, the Neotropical species of which have been listed by the writer in recent papers (Rev. de Entomologia, 17: 375–400, 1946; 18: 65–100, 1947; 18: 317–360, 1947).

Genus **Trentepohlia** Bigot

Trentepohlia (**Paramongoma**) **tethys** sp. n.

General coloration dark brown; pleura and pleurotergite yellow; legs with the femora brown, the tips broadly white; tibiae black, the bases white, the tips more broadly so; basitarsi black, the outer third and remainder of tarsi white; wings subhyaline, stigma pale brown, triangular; extreme wing tip vaguely darkened; vein R_5 oblique, in approximate longitudinal alignment with R_{2+3+4}.

Female.—Length, about 11 mm.; wing, 8.5 mm.

Rostrum yellow; basal two segments of palpi yellow, the outer two dark brown. Antennae with the scape and pedicel testaceous yellow, flagellum brownish black; flagellar segments elongate-oval to subcylindrical, verticils short. Front yellow; posterior part of head dark brownish gray; anterior vertex narrow, scarcely one-half the diameter of scape.

Pronotum brown. Mesonotum chiefly dark brown, the surface sparsely pruinose, more heavily so on the scutellum and mediotergite; humeral region of praescutum and central part of scutum obscure yellow; pleura and pleurotergite yellow, the mesepisternum a trifle more obscured. Halteres brownish black. Legs with the coxae and trochanters yellow, the fore coxae a trifle darker; femora brown, vaguely paler at bases, the tips broadly and abruptly snowy white; tibiae black, the bases similarly snowy white, a trifle more extensive than the femoral tips; tibial tips abruptly snowy white, a little more dilated, approximately twice the whitened bases; basitarsi black, the outer third or slightly more, as well as the remainder of tarsi, snowy white. Wings subhyaline; stigma pale brown, small, triangular in outline; extreme wing tip vaguely darkened; veins dark brown, *C*, *Sc* and *R* in the vicinity

[1]Contribution from the Entomological Laboratory, University of Massachusetts. The preceding part under this general title was published in the ANNALS OF THE ENTOMOLOGICAL SOCIETY OF AMERICA, 38: 356–380, 1945.

of the stigma paler brown. Venation: Sc_2 before the level of fork of Rs; R_2 about three times R_{3+4}; vein R_3 oblique, in approximate longitudinal alignment with R_{2+3+4}; *m-cu* about two-fifths its length before the fork of M.

Abdominal tergites dark brown; sternites pale greenish yellow.

Habitat.—Peru (Huanuco). *Holotype*, ♀, Fundo Sinchono, altitude 1500 meters, August 4, 1947 (Schunke).

The most similar described species is *Trentepohlia* (*Paramongoma*) *metatarsata* Alexander, which differs in the coloration of the legs and in the venation.

Trentepohlia (Paramongoma) conscripta sp. n.

General coloration brown, the praescutum somewhat darker medially; legs brown, the tarsi paling to yellow; wings with a pale brownish tinge, unpatterned except for the small brown stigma; R_{2+3+4} a trifle longer than R_{3+4}; cell *1st* M_2 large, subequal to the distal section of vein M_3; distance on margin between veins Cu_1 and *1st* A extensive, nearly equal to *m-cu*.

Male.—Length, about 6 mm.; wing, 7.3 mm.

Rostrum brown; palpi black. Antennae black throughout; flagellar segments oval, the verticils short. Head brown; anterior vertex very reduced.

Cervical region and pronotum brownish black. Mesonotum brown, the praescutum somewhat darker medially; pleurotergite and pleura somewhat more yellowish brown. Halteres infuscated. Legs with the coxae and trochanters brownish testaceous; remainder of legs brown, the tarsi paling to yellow. Wings with a pale brownish tinge, unpatterned except for the small oval brown stigma; prearcular and costal cells pale yellow; veins pale brown, Sc more yellowed. Venation: Sc_1 ending about opposite R_2; R_{2+3+4} a trifle longer than R_{3+4}; cell *1st* M_2 large, subequal to the distal section of vein M_3; *m-cu* shortly beyond the fork of M; distance on margin between Cu_1 and *1st* A extensive, nearly equal to *m-cu*.

Abdominal tergites brown, the sternites and hypopygium more brownish yellow.

Habitat.—Peru (Huanuco). *Holotype*, ♂, Carpish, in dwarf fog forests, altitude 2800 meters, October 10, 1946 (Woytkowski). *Paratopotype*, ♂.

The most similar species is *Trentepohlia* (*Paramongoma*) *longifusa* Alexander, which is well distinguished by the small size and by details of coloration and venation.

Trentepohlia (Paramongoma) montivaga sp. n.

Size relatively large (wing, male, 6.5 mm. or over); general coloration uniformly pale yellow, including the halteres and legs; wings pale yellow, with a restricted darkened seam over the distal section of vein Cu; vein R_3 oblique, only a little longer than R_{3+4}; cell *1st* M_2 large, only a little shorter than the distal section of vein R_5.

Male.—Length, about 5–5.5 mm.; wing, 6.5–6.7 mm.

Female.—Length, about 6.5–7 mm.; wing, 7.5–8 mm.

Rostrum yellow, the reduced palpi infuscated. Antennae with the scape yellow, pedicel light brown, flagellum dark brown; flagellar segments oval, the verticils short and inconspicuous. Head buffy yellow; anterior vertex reduced to a linear strip.

Thorax uniformly yellow. Halteres uniformly pale. Legs yellow, the terminal tarsal segments weakly more darkened. Wings pale yellow, the prearcular and costal regions clearer yellow; a faintly indicated darkened seam on distal section of vein Cu_1; veins yellow, Cu_1 on its distal section especially more darkened. Venation: *Rs* arcuated; vein R_3 oblique, only a little longer than R_{3+4}; cell *1st* M_2 large, only a trifle shorter than the distal section of vein R_5; distal section of vein Cu_1 variable in length, from subequal to fully twice *m-cu*.

Abdomen obscure brownish yellow; hypopygium, excepting the blackened dististyles, clearer yellow.

Habitat.—Peru (Huanuco). *Holotype*, ♂, Sariapampa, in fog forest, altitude 3600 meters, May 12, 1946 (Woytkowski). *Allotopotype*, ♀. *Paratopotypes*, several ♂♂ ♀♀.

Although very similar in its general appearance to *Trentepohlia* (*Paramongoma*) *cubitalis* Alexander, of southeastern Brazil, the present fly is obviously distinct, differing particularly in the large size and in the details of venation.

Genus **Teucholabis** Osten Sacken

Teucholabis (**Paratropesa**) **nodulifera** sp. n.

Belongs to the *collaris* group. Pronotum light yellow, mesonotum purplish black; knobs of halteres light yellow; middle legs yellow; posterior femora yellow with two black rings; an unusually large dilation on more than the proximal half of the posterior basitarsus; wings pale yellow, conspicuously patterned with brown; basal dark band crossing both Anal cells to the margin, occupying half the extent of cell *2nd A*; abdomen black, the posterior borders of the sternites broadly yellow; mesal face of basistyle produced into a slender spine; outer dististyle terminating in a pale spine; aedeagus at apex with an abundance of strong setae, the apex a curved black spine.

Male.—Length, about 8 mm.; wing, 7.4 mm.

Rostrum yellow; palpi black. Antennae with the scape yellow below, more infuscated above; flagellum black; flagellar segments oval. Head above chiefly brownish black, the anterior vertex and posterior portion of the head more brownish yellow.

Prothorax uniformly pale yellow. Mesonotum polished black, the praescutum with vague purplish reflexions. Pleura black, the dorsopleural region restrictedly pale; areas of gray bloom or pubescence above the middle and posterior coxae, apparently representing extensive silvery patches in fresh specimens. Halteres black, the knobs light yellow. Legs with the fore and middle coxae and trochanters light yellow, posterior coxae and trochanters black; fore legs broken; middle legs obscure yellow, the tarsi passing into brown; posterior femora yellow, with two black rings, one subbasal, the other subapical, the latter a little narrower and about one-half as extensive as the intervening yellow band; tibiae obscure yellow; tarsi obscure yellow, the basitarsi with more than

the proximal half dilated and blackened; outer tarsal segments brownish black; nodulose area on basitarsus, as described, larger and more conspicuous than in the other similar described species, being approximately three times as thick as the apical diameter of the segment. Wings pale yellow, conspicuously patterned with brown, as follows: A narrow band at cord, narrower and more intense at stigma, widened behind at the posterior border in cell *1st A*; wing tip more broadly infuscated, extending basad to the level of the outer end of cell *1st* M_2 and fork of R_{3+4}; basad of cord, the darkenings restricted, very narrow at arculus, more expanded but paler in cells *Cu*, *1st A* and *2nd A*, occupying about one-half the extent of the last cell; veins brown, not or scarcely paler in the ground areas. Venation: R_2 just basad of *r-m* producing a short element R_{3+4+5}; vein R_3 weakly sinuous, about one-third R_4; R_5 extensively fused with M_{1+2}, as in the group; cell *1st* M_2 narrow; *m-cu* at fork of *M*.

Abdomen black, the broad posterior borders of the sternites light yellow; subterminal segments and hypopygium black. Sternal pocket of segment five large and conspicuous, covering virtually the entire length of the segment, widened behind, the narrow cephalic end with a semilunate chitinized area; setae lateral, directed inward, the more caudal ones chiefly longer and more slender. Male hypopygium with the apical lobe of the basistyle slender, terminating in a short blackened point; mesal face of style, near base, with a strong erect black spine. Outer dististyle a small slender rod, its basal two-thirds more dilated, provided with about nine strong setae; outer third of style a straight pale spine. Inner dististyle large, complex in structure, the flattened beak black; basal arm with about a dozen strong setae. Aedeagus complex, dilated near apex and here provided with very numerous strong setae, the apex a curved black spine.

Habitat.—Peru (Huanuco). *Holotype*, ♂, Fundo Sinchono, altitude 1500 meters, August 4, 1947 (Schunke).

From the various other members of the *collaris* group, including *Teucholabis* (*Paratropesa*) *collaris* (Osten Sacken), the present fly differs in the diagnostic features listed, including the leg and wing pattern and structure of the legs and male hypopygium.

Teucholabis (Teucholabis) ducalis sp. n.

Size large (wing, male, 8 mm. or more); general coloration black, the scutellum broadly light yellow; halteres with stem black, knob yellow; femora yellow, the tips broadly black; tarsi black; wings pale yellow, very heavily patterned with dark brown, including the narrow costal border, broad wing tip and narrow posterior margin; cord narrowly seamed with darker brown; male hypopygium with the spine of the basistyle stout-based; outer dististyle dilated on outer half, at near midlength with a strong spine.

Male.—Length, about 7–7.3 mm.; wing, 8–8.5 mm.

Rostrum short, approximately one-half the remainder of head, black throughout; palpi black. Antennae black throughout; basal five or six flagellar segments large, suboval, slightly produced apically on ventral face; outer segments oval; verticils shorter than the segments. Head dull black.

Pronotal scutum black, the scutellum and pretergites yellow. Mesonotum polished black, the scutellum broadly light yellow; a more restricted yellow median area at suture, involving parts of the praescutum and scutum. Pleura black, with a vague pruinose area on the posterior pleurites; dorsopleural region yellow. Halteres with stem black, knob yellow. Legs with all coxae and trochanters black; femora yellow, the tips broadly and conspicuously blackened, subequal in amount on all legs, including nearly the outer third on the fore and middle legs, the outer fifth on the more lengthened posterior femora; tibiae light to dark brown, the tips narrowly blackened; tarsi black; glandular area of posterior basitarsus only feebly dilated. Wings pale yellow, very heavily and conspicuously patterned with dark brown, including cells *C* and *Sc*; the broad wing tip, this continued around the posterior margin of wing as a narrow border; stigma, cord and outer end of cell *1st* M_2 narrowly darker brown; vague brown clouds or washes in the basal wing cells; veins brownish black. Venation: Sc_1 ending about opposite two-thirds the length of *Rs*; R_{2+3+4} very short.

Abdomen, including hypopygium, black. Sternal pocket of segment five appearing as a long triangular area, narrowed in front, the inner vestiture consisting of relatively long black setae directed mesad; outer setae strong and powerful, likewise directed mesad. Male hypopygium with the spine of the basistyle near apex of mesal face, a stout-based rod that narrows at midlength into a strong black spine, at the point of narrowing with a dense brush of yellow setae; mesal flange not conspicuously crenulated or toothed. Outer dististyle a strong rod, the basal half a slender stem, the outer half more dilated or bulbous, the apex weekly bidentate; on mesal face at base of the expanded portion with a powerful spine, the opposite margin of style microscopically scabrous. Inner dististyle with the beak terminating in a cultriform blade, the usual lower spine replaced by a series of five or six weak serrations. Aedeagus terminating in a stout blackened subapical spine, the protruded axis with two pairs of setae, the more lateral ones stouter.

Habitat.—Peru (Huanuco). *Holotype*, ♂, Fundo Sinchono, altitude 1500 meters, August 6, 1947 (Schunke). *Paratopotypes*, 3 ♂♂, August 6–28, 1947 (Schunke).

This large and striking species is not closely related to others so far described. Superficially it suggests species such as *Teucholabis* (*Teucholabis*) *decora* Alexander, despite the body coloration, but all structures of the male hypopygium are distinct.

Teucholabis (Teucholabis) subanthracina sp. n.

Allied to *anthracina*. General coloration of body polished black; thoracic pleura with a broad longitudinal more silvery stripe; wings subhyaline, patterned with brown, including a narrow band at cord and the broader wing tip; Sc_1 ending about opposite two-thirds the length of *Rs*; male hypopygium with the outer dististyle long, terminating in two short spines, with a further slender spine on mesal edge at near midlength; inner dististyle with the beak produced into a single point, the lower or subapical one obsolete; lobe of style tipped with about six short stout spines of approximately equal size.

Male.—Length, about 6 mm.; wing, 4.9–5 mm.

Rostrum long and slender, subequal in length to the remainder of head, black, longer than in *anthracina*; palpi black. Antennae black throughout; flagellar segments oval, smaller and slightly more elongated outwardly, shorter than the verticils. Head black.

Thorax almost uniformly polished black, the pronotal scutellum and pretergites more reddened; mesonotal scutellum brownish black; dorsopleural membrane dark. Thoracic pleura with a broad longitudinal more silvery stripe extending from behind the fore coxae to the base of abdomen, passing beneath the root of the halteres. Halteres infuscated, knobs obscure yellow. Legs with all coxae black; trochanters dark brown; femora brownish black, the bases obscure yellow, involving approximately the basal half or less, the tips more blackened; tibiae brownish black; tarsi black; posterior basitarsi moderately dilated on proximal third. Wings subhyaline, patterned with pale brown, including a narrow band at cord and the broader apex, the latter not including the bases of cells *2nd* M_2 and M_3; stigma oval, darker brown; cells basad of cord not or scarcely darkened. Venation: Sc_1 ending about opposite two-thirds the length of *Rs*, Sc_2 just beyond one-fourth the length of *Rs*; branches of *Rs* parallel for most of their lengths, R_5 thence diverging strongly almost to the wing tip; *m-cu* from one-third to one-half its length beyond the fork of *M*.

Abdomen, including hypopygium, black. Sternal pocket of segment five placed near the posterior end of segment, long-oval, the center with microscopic setulae, the border with relatively few long strong bristles that are directed mesad; on sternite six with about a dozen strong setae in a longitudinal row on either side of the broad midline, the rows slightly more narrowed behind; an even weaker sternal area on segment seven, including five or six weak setae on either side of a median area. Male hypopygium with the spine of the basistyle on mesal face just beyond midlength, stout, extended at tip into a strong black spine; mesal margin with a row of long yellow setae; mesal flange blackened, conspicuous, the margin coarsely crenulate. Outer dististyle long, terminating in two short spines, with a long slender spine on mesal edge at near midlength; surface of style with numerous long coarse setae. Inner dististyle with the outer arm or beak produced into a single developed spine; lobe of style terminating in about six or seven short stout spines of approximately equal size. Aedeagus terminating in a strong blackened spine; surface of organ, at near midlength, with four long setae.

Habitat.—Ecuador (Santiago-Zamora). *Holotype*, ♂, Zumbi, Rio Zamora, altitude 700 meters, October 28, 1941 (Laddey). *Paratopotype*, ♂, October 31, 1941 (Laddey).

Although very similar in its general appearance to *Teucholabis* (*Teucholabis*) *anthracina* Alexander, the present fly seems to be quite distinct in the hypopygial characters, as above described. The type specimens had earlier (Rev. de Entomologia, 16: 374; 1945) been identified as *anthracina*.

Teucholabis (Teucholabis) desdemona sp. n.

Size small (wing, male, about 4.5 mm.); general coloration polished black, variegated with yellow, including the scutellum; knobs of halteres

yellow; wings whitish, restrictedly patterned with brown, most conspicuous as the stigma and over the anterior cord; *Sc* short, Sc_1 ending about opposite one-fourth the length of *Rs*, the branches of the latter strongly divergent; cell M_2 normally open by the atrophy of the basal section of M_3; abdominal segments bicolored, black and yellow; male hypopygium without an apical spine on basistyle; outer dististyle a long rod bearing a lateral spine at near two-thirds the length, terminating in a long straight spine; aedeagus with the apical point directed laterad.

Male.—Length, about 4–4.5 mm.; wing, 4–4.6 mm.

Rostrum short, black; palpi black. Antennae relatively long, if bent backward extending about to the root of wings; scape and pedicel obscure yellow, flagellum black; flagellar segments short-oval, strongly narrowed at outer ends, shorter than the verticils. Head polished black.

Prothorax and pretergites uniformly pale yellow. Mesonotum polished black, the scutellum and a central spot at suture yellow. Pleura chiefly occupied by a broad yellow longitudinal stripe extending from the prothorax across the dorsal sternopleurite, becoming more expanded on the meral and metapleural regions, the surface silvery pollinose; a large isolated black area on the ventral sternopleurite. Halteres brownish black, the knobs yellow. Legs with all coxae and trochanters yellow; fore femora black, the bases broadly yellow; tibiae yellowish brown, the tips blackened; tarsi black; middle and hind legs yellow, the tips of the femora and tibiae narrowly blackened; tarsi black; posterior basitarsi dilated on proximal third. Wings whitish, restrictedly patterned with brown, including cell Sc, stigma, a seam along the cord and a more or less distinct cloud at the outer medial fork; veins brown, those of the wing base more yellowed. Venation: *Sc* short, Sc_1 ending about opposite one-fourth to one-fifth *Rs*, Sc_2 a short distance beyond this origin; R_2 at or close to fork of *Rs*; branches of *Rs* strongly divergent, R_5 bent strongly caudad to the wing tip, cell R_4 thus very wide, at least five times cell R_5; cell M_2 normally open by the atrophy of basal section of vein M_3, in one specimen, cell *1st* M_2 closed; cell M_4 distinctly narrowed at margin; *m-cu* close to fork of *M*.

Abdominal segments bicolored, black, the posterior borders of the intermediate segments broadly yellow; subterminal segments more uniformly yellow; hypopygium uniformly blackened. Sternal pocket of segment five broad, with abundant setae; of segment six with less numerous but stouter setae that are directed inward, arranged in two more or less parallel rows. Male hypopygium with the apex of basistyle obtuse, without a spine; mesal flange long and narrow, blackened, its margin weakly crenate. Outer dististyle a long rod, dilated on basal half and here with scattered setae and appressed spinulae, at near two-thirds the length with an appressed lateral spine, beyond which the style narrows into a long nearly straight spine. Inner dististyle without setae, the lower beak weakly bidentate. Aedeagus with the apical spine directed laterad, blunt at tip; surface of aedeagus with relatively numerous though not particularly strong setae.

Habitat.—Peru (Loreto). *Holotype*, ♂, Pucallpa, altitude 180 meters, March 22, 1947 (Schunke). *Paratopotypes*, 4 ♂♂, March 19-20, 1947 (Schunke).

From the other species of *Teucholabis* having no spine on the basi-

style of the male hypopygium, the present fly is readily told by the small size, coloration of the body and wings, and by the normally open cell M_2.

Genus **Gnophomyia** Osten Sacken

Gnophomyia (**Eugnophomyia**) **flammeithorax** sp. n.

Allied to *tempestiva*. General coloration black, the thorax, including the pleura and sternum, uniformly bright orange, only the region of the metapleura blackened; antennae, halteres and legs black; wings with a strong blackish tinge; macrotrichia of cells beyond cord unusually numerous; R_2 subequal to R_{2+3+4} and more than twice R_{3+4}.

Female.—Length, about 6.5 mm.; wing, 7.8 mm.; antenna, about 1.8 mm.

Rostrum and palpi black. Antennae black throughout; basal flagellar segments very short-cylindrical, the outer ones passing into oval; verticils subequal to or a trifle exceeding the segments. Head black.

Pronotum and propleura black. Mesonotum and pleura, with the sternum, uniformly bright orange,excepting only the meral and metapleural area above the hind legs. Halteres and legs uniformly black. Wings with a strong blackish tinge, the prearcular and costal fields slightly darker; stigma small, still darker brown; veins brownish black. Macrotrichia of cells beyond cord unusually numerous and conspicuous, lacking in the bases of the cells. Venation: Sc_1 ending just before the level of the fork of *Rs*, Sc_2 close to its tip; R_2 subequal to R_{2+3+4} and more than twice R_{3+4}; *m-cu* about one-third its length beyond the fork of *M*.

Abdomen uniformly black. Ovipositor with the valves strongly developed, dark horn yellow.

Habitat.—Peru (Huanuco). *Holotype*, ♀, Carpish, in dwarf fog forests, altitude 2800 meters, October 2, 1946 (Woytkowski).

Among the various species of the subgenus having the thorax variously patterned with orange, the present fly is closest to species such as *Gnophomyia* (*Eugnophomyia*) *flagrans* Alexander and *G.* (*E.*) *tempestiva* Alexander, differing in the very extensive orange color of the thorax and in details of venation and trichiation of the wings.

Gnophomyia (**Gnophomyia**) **magniarcuata** sp. n.

Belongs to the *arcuata* group. Size very large (wing, female, 8 mm.); mesonotal praescutum almost uniformly plumbeous, pseudosutural foveae black; wings whitish subhyaline, stigma dark brown; vein Sc_1 very long, approximately three-fourths as long as *Rs*; *m-cu* about one-half its length before the fork of *M*.

Female.—Length, about 8 mm.; wing, 8 mm.

Rostrum gray pruinose; palpi black. Antennae black throughout; flagellar segments cylindrical, longer than the verticils. Head dark gray; anterior vertex broad, fully three times the diameter of scape.

Pronotum dark brownish gray; pretergites dark. Mesonotal praescutum almost uniformly dark gray or plumbeous; pseudosutural foveae black, extensive; posterior portion of scutal lobes, scutellum and

postnotum clear light gray, the mediotergite darker posteriorly. Pleura in front dark plumbeous gray, clear light gray behind, including the coxae. Halteres blackened. Legs with the coxae light gray; remainder of legs black. Wings whitish subhyaline; stigma dark brown; extreme wing base, including squama and the region of arculus, vaguely darkened; veins black. Venation: *Sc* long, Sc_1 ending just before the fork of *Rs*, Sc_2 far retracted so Sc_1 is very long, approximately three-fourths *Rs*; R_{2+3+4} very strongly arcuated to subperpendicular at origin; R_{3+4} shorter than R_2; vein R_4 deflected strongly caudad on outer half, ending close to the wing tip; *m-cu* about one-half its length before the fork of *M*.

Abdomen elongate, black. Ovipositor with the cerci elongate, compressed-flattened; hypovalve much shorter, approximately one-third as long.

Habitat.—Peru (Huanuco). *Holotype*, ♀, Huamincha, forest zone, altitude 1600 meters, April 4, 1946 (Woytkowski).

The other described members of the group, including *Gnophomyia* (*Gnophomyia*) *arcuata* Alexander, *G.* (*G.*) *diazi* Alexander, and *G.* (*G.*) *subarcuata* Alexander, are all much smaller, with vein Sc_1 shorter.

Gnophomyia (Gnophomyia) perdebilis sp. n.

Belongs to the *tristissima* group. Allied to *maestitia*; general coloration black, the meral and metapleural region of thorax paling to yellow; antennae unusually long, approximately one-half the entire body; halteres black; wings with a strong blackish tinge, with somewhat darker washes over the anterior cord, in bases of cells *R* and *M* and along vein *Cu* in cell *M*; prearcular and costal fields more whitened; male hypopygium with the tergite conspicuous, its posterior margin with a row of scattered weak setae; mesal face of basistyle virtually unarmed; inner dististyle unusually long, approximately one-half as long as the simple outer style.

Male.—Length, about 5.5 mm.; wing, 6 mm.; antenna, about 2.7–2.8 mm.

Female.—Length, about 5.5 mm.; wing, 6 mm.

Rostrum and palpi black. Antennae (male) of unusual length for a member of the group, approximately one-half the length of body, black throughout; flagellar segments elongate-fusiform, narrowed at either end, subequal to the longest verticils. Head black, the front and anterior vertex more pruinose; anterior vertex broad, approximately four times the diameter of scape.

Pronotum and mesonotum black, the very restricted pretergites a trifle paler. Pleura dull black on dorsal portion, gray pruinose ventrally, the meral and metapleural regions paling to light yellow. Halteres uniformly black. Legs black. Wings with a strong blackish tinge, the elongate stigma darker brown; more dusky washes over the anterior cord, bases of cells *R* and *M*, and along vein *Cu* in cell *M*; prearcular and costal fields more whitened; a pale area near outer ends of cells *R* and *M* before cord; veins black. Venation: Sc_1 ending just beyond the fork of R_{2+3+4}; *r-m* just before the fork of the nearly straight *Rs*; *m-cu* at or close to midlength of cell *1st* M_2.

Abdomen, including the genitalia, black throughout. Male hypopygium with the ninth tergite transverse, subrectangular, the caudal margin

with a row of scattered weak seta-like fimbriations, slightly more concentrated at the outer lateral portions; lateral fourth of tergal plate slightly more darkened, with scattered long coarse setae. Basistyle short and stout, the mesal face with about five strong slender setae but without further vestiture. Outer dististyle a stout flattened black blade, the apex obtuse. Inner dististyle unusually long, approximately one-half as long as the outer dististyle, apical portion strongly bent, the tip obtuse; distal half of style, especially the apex, with scattered strong setae, some much longer.

Habitat.—Peru (Huanuco). *Holotype*, ♂, Fundo Sinchono, altitude 1500 meters, August 1, 1947 (Schunke). *Allotopotype*, ♀, pinned with type. *Paratopotypes*, 7 ♂♂, January and August 1947 (Schunke).

The present fly is readily told from the most similar species, including *Gnophomyia* (*Gnophomyia*) *kertesziana* Alexander, *G.* (*G.*) *maestitia* Alexander, and *G.* (*G.*) *podacantha* Alexander, by the structure of the male hypopygium, especially the scarcely modified ninth tergite and the dististyles. The spines and fimbriations of the tergite in all of the now known numerous species appear to be direct extensions of the tergal plate rather than modified setae.

Gnophomyia (Gnophomyia) petentis sp. n.

Belongs to the *tristissima* group, allied to *maestitia*. Body and appendages black; antennae (male) unusually long, approximately one-half the length of the wing; wings with a strong blackish tinge; brown clouds over the anterior cord and along vein *Cu* in cell *M*; male hypopygium with the tergite large, the caudal margin nearly truncate, with a double row of strong spines, the lateral angles produced and tufted with longer spines; basistyle on mesal face at base bearing a strong blackened rod from an expanded ear-like base, with a further smaller spine on style near outer end; inner dististyle long-oval, terminating in a blackened spinous point; aedeagus long and slender.

Male.—Length, about 5–5.5 mm.; wing, 5–6 mm.; antenna, about 2.5–2.7 mm.

Female.—Length, about 6.5 mm.; wing, 5.5 mm.

Entire body, with the palpi, antennae, halteres and legs, black; anterior pretergites with a small yellow area. Antennae unusually long, as shown by the measurements; flagellar segments elongate-subcylindrical or slightly dilated at midlength, a little shorter than the verticils. Wings with a strong blackish tinge, the stigma elongate, still darker; brown clouds, intermediate in color, over the anterior cord and along vein *Cu* in cell *M*; veins brownish black. Venation: *Rs* nearly straight; basal section of R_5 lacking or virtually so, *Rs* in alignment with R_5; *m-cu* at near midlength of cell *1st* M_2.

Male hypopygium with the tergite large, the caudal margin nearly truncate, with a double row of strong spines, totalling about 80 to 90; lateral ends of tergal plate produced, bearing about a dozen longer black spines. Basistyle on mesal face of proximal end bearing a very strong blackened rod with a flattened ear-like base; near outer end of style on mesal face with a further smaller strong spine. Outer dististyle a simple gently curved rod, the tip obtuse. Inner dististyle small, long-oval, terminating in a blackened spinous point; surface with several

setae, the longest subequal in length to the style itself. Aedeagus long and slender.

Habitat.—Peru (Huanuco). *Holotype*, ♂, Fundo Sinchono, altitude 1600 meters, August 25, 1947 (Schunke). *Allotopotype*, ♀. *Paratopotype*, ♂, August 2, 1947 (Schunke).

The most similar described species include *Gnophomyia* (*Gnophomyia*) *kertesziana* Alexander, *G.* (*G.*) *podacantha* Alexander, *G.* (*G.*) *permagica* Alexander, and *G.* (*G.*) *tungurahuana* Alexander, all of which differ conspicuously among themselves and from the present fly in the structure of the male hypopygium.

Gnophomyia (Gnophomyia) trisetigera sp. n.

General coloration black, including also the antennae, halteres and legs; antennae (male) relatively long, nearly one-half the body; pleura with a broad silvery longitudinal stripe on the dorsal sternopleurite, paling to yellow on the meral region; halteres brownish black; wings with a strong brownish tinge, vaguely patterned with still darker brown; *r-m* at fork of *Rs*; R_2 nearly obsolete, transverse; male hypopygium with the tergite large, conspicuously emarginate by a V-shaped notch, the margins of the lobes without spines or modified setae; basistyle on mesal face of cephalic end with a strong dusky lobe that bears three strong setae; inner dististyle bilobed on outer half, both lobes bearing relatively few setae.

Male.—Length, about 5.5 mm.; wing, 5.8 mm.; antenna, about 2.5 mm.

Rostrum and palpi black. Antennae (male) relatively long, nearly one-half the body, black throughout; flagellar segments elongate-subcylindrical, the longest verticils subequal to or slightly longer than the segments. Head dull black; anterior vertex very broad, nearly four times the diameter of the scape; a low tubercle on anterior vertex.

Pronotum brownish black; anterior pretergites and lateral ends of the pronotal scutellum yellow. Mesonotum black, the scutellum and mediotergite slightly pruinose. Pleura black, with a broad silvery longitudinal stripe on the dorsal sternopleurite, paling to yellow on the ventral pteropleurite and meral region; dorsopleural membrane infuscated. Halteres brownish black. Legs with the fore coxae brownish black, the middle and posterior pairs paler; trochanters brown; remainder of legs black. Wings with a strong brownish tinge, even deeper in color over the anterior cord and in cell *M* adjoining vein *Cu*; stigma elongate, darker brown; veins brownish black. Venation: Sc_1 ending nearly opposite the fork of R_{2+3+4}, Sc_2 some distance from its tip; *r-m* at fork of *Rs*; vein R_2 nearly obsolete, transverse; cell *1st* M_2 long, with *m-cu* just before midlength. The right wing of the holotype has an adventitious crossvein near the base of cell *2nd* M_2.

Abdomen black. Male hypopygium with the ninth tergite large, conspicuously emarginate by a V-shaped notch, the margins of the broad lobes thus formed smooth; dorsum of each lobe with about a dozen strong setae. Basistyle short and stout, near base of mesal face with a strong dusky tubercle bearing three strong setae. Outer dististyle a simple slender glabrous rod, its tip obtuse. Inner dististyle bilobed on outer half, the outer arm or lobe longest, both lobes bearing few setae. Apex of phallosome emarginate.

Habitat.—Peru (Huanuco). *Holotype*, ♂, Fundo Sinchono, altitude 1500 meters, August 2, 1947 (Schunke). *Allotopotype*, ♀, pinned with type.

While generally similar in appearance to species such as ***Gnophomyia*** **(*Gnophomyia*)** ***maestitia*** Alexander and related species, the present fly is entirely distinct in the structure of the male hypopygium, particularly the tergite, basistyle and inner dististyle.

Gnophomyia (Gnophomyia) socialis sp. n.

General coloration of praescutum brownish gray, paling to reddish brown on sides; thoracic pleura striped with brownish black; halteres yellow, knob dark brown; femora yellow, the tips narrowly dark brown; wings yellow, restrictedly patterned with brown, best indicated by a darkening of the cord and outer end of cell *1st* M_2; vein R_2 close to the fork of R_{2+3+4}, about one-third R_{1+2}; cell *1st* M_2 long and narrow; male hypopygium with the inner dististyle bilobed, both lobes blackened.

Male.—Length, about 6 mm.; wing, 6.5 mm.

Rostrum yellow; palpi brown. Antennae with scape and pedicel obscure testaceous yellow, flagellum black, the first segment paler; flagellar segments oval, slightly shorter than their verticils. Head yellow.

Pronotum yellow above, brown on the sides; pretergites whitened. Mesonotal praescutum brownish gray medially, paling to reddish brown on sides, humeral region and lateral border pale yellow; posterior sclerites of notum dark brown; posterior angles of scutal lobes obscure yellow; posterior border of scutellum yellow. Pleura and pleurotergite yellow, with a broad conspicuous brownish black longitudinal stripe extending from the cervical region across the dorsal pleurites, merging gradually with the yellow ground of the ventral edge; dorsopleural membrane abruptly yellow. Halteres with stem light yellow, knob dark brown. Legs with coxae and trochanters pale yellow; femora yellow, the tips narrowly dark brown; remainder of legs yellow, the outer tarsal segments infuscated. Wings with the ground yellow, the prearcular and costal fields even clearer yellow; a restricted brown pattern, including the stigma, cord and outer end of cell *1st* M_2, the latter two best-indicated by the darkened veins; very pale brown washes near outer end of cell *M* and across bases of cells *Cu* and *2nd A*; veins yellow, those beyond cord somewhat darker. Venation: Sc_1 ending a short distance before the level of vein R_2; *r-m* shortly before the fork of *Rs*; R_2 at or close to fork of R_{2+3+4}, about one-third R_{1+2}; veins R_3 and R_4 long, generally parallel to one another for their entire lengths; cell *1st* M_2 long and narrow, gently widened outwardly; *m-cu* at near midlength of M_{3+4}.

Abdominal tergites brownish black, the lateral borders narrowly pale. Male hypopygium with the basistyle short and stout, unarmed. Outer dististyle a simple blackened rod, the tip obtuse, the mesal face at near midlength microscopically scabrous. Inner dististyle unusually compact, unequally bilobed, the outer lobe a blackened knob, the tip obtuse, the inner lobe smaller, likewise blackened; surface of style above with a transverse row of five strong bristles. Phallosome depressed-flattened, terminating in a central blackened knob, its tip obtuse.

Habitat.—Peru (Huanuco). *Holotype*, ♂, Chinchao, altitude 2500 meters, in wooded hills, September 20, 1947 (George Woytkowski).

Among the other regional species that have the wings slightly patterned with darker, including *Gnophomyia* (*Gnophomyia*) *argutula* Alexander, *G.* (*G.*) *duplex* Alexander, and *G.* (*G.*) *regnatrix* Alexander, the present fly is most similar to the last in general coloration and wing pattern. It differs conspicuously in the small size and in the details of venation. The male sex of *regnatrix* is still unknown.

Gnophomyia (**Gnophomyia**) **subflebilis** sp. n.

Male.—Length, about 5 mm.; wing, 5.5 mm.; antenna, about 1.1 mm.

Characters generally as in *flebilis* Alexander, differing in important hypopygial characters. Wings with the base not so scarcely brightened; stigma present but very narrow. Male hypopygium having the ninth tergite with its caudal margin very gently convex, on either side of the midline and widely separated with a stout darkened tubercle. Outer dististyle unusually long and slender, narrowed very gradually to the acute tip. Inner dististyle with the basal lobe low, provided with two strong setae, the remainder of upper face of style with nine further similar setae; ventral surface of apex with a further group of short spinous setae. Phallosome relatively narrow, the apex blackened, obtuse.

Habitat.—Ecuador (Santiago-Zamora). *Holotype*, ♂, Zumbi, Rio Zamora, altitude 700 meters, November 1, 1941 (Laddey).

The present fly is close to *Gnophomyia* (*Gnophomyia*) *flebilis* Alexander and *G.* (*G.*) *peracutior* sp. n., the chief distinctions being found in the structure of the male hypopygium. Both *peracutior* and *subflebilis* have the knobs of the halteres deep yellow.

Gnophomyia (**Gnophomyia**) **peracutior** sp. n.

General coloration black, the posterior pleurites faintly pruinose; halteres with stem blackened, knob deep yellow; femora brownish black; wings with a strong brownish tinge, more yellowed at base; no stigmal darkening; R_{1+2} relatively long, exceeding one-half *Rs*; male hypopygium with inconspicuous lateral tergal tubercles; outer dististyle gradually narrowed into a long acute spine.

Male.—Length, about 5.5 mm.; wing, 6 mm.; antenna, about 1.4 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments oval. Head black.

Thorax almost uniformly black, the surface subnitidous; pretergites narrowly obscure yellow; posterior pleurites faintly pruinose, more heavily so on the metapleural region; meron paler. Halteres with stem blackened, knob deep yellow. Legs with the coxae brownish black; trochanters brownish yellow; femora brownish black, the bases narrowly more yellowed, most evidently so on the posterior pair; tibiae and tarsi brownish black to black. Wings with a strong brownish tinge, the prearcular field narrowly but conspicuously yellow; no evidence of a stigmal darkening; veins brown, pale in the brightened basal portions. Venation: *Rs* gently arcuated, not as extended basally as in *subflebilis*; R_{1+2} longer than in the latter species, exceeding one-half the length of *Rs*; cells beyond cord longer than in *subflebilis*.

Abdomen, including hypopygium, brownish black. Male hypopygium with the outer lateral angles of the tergite terminating in a small inconspicuous tubercle; from beneath the tergite juts caudad what is presumed to be the proctiger, each outer lateral angle of which bears a single strong seta. Outer dististyle long and slender, gradually narrowed into a long acute spine, this apparently more slender than in *subflebilis*. Inner dististyle stout, with about four strong setae on the low basal lobe and six others more distad. Phallosome terminating in a relatively narrow blackened knob.

Habitat.—Peru (Huanuco). *Holotype*, ♂, Fundo Sinchono, altitude 1500 meters, August 5, 1947 (Schunke).

This fly is most nearly allied to ***Gnophomyia* (*Gnophomyia*) *subflebilis*** sp. n., differing especially in the coloration of the body and wings and in the details of venation and structure of the male hypopygium.

Gnophomyia (Gnophomyia) tricornis sp. n.

General coloration of the body black, the mesonotum subnitidous; anterior pretergites restrictedly yellow; metapleural region and knobs of halteres abruptly yellow; wings whitish subhyaline, stigma large, pale brown, inconspicuous; *r-m* at or before the fork of *Rs*; R_2 very faint to virtually obsolete; cell *1st* M_2 elongate; male hypopygium with the outer dististyle a strong glabrous rod, narrowed to the obtuse more yellowed apex; inner dististyle with two arms, the basal lobe being unusually long, approximately two-thirds the main axis of the style.

Male.—Length, about 5.2–5.3 mm.; wing, 6 mm.; antenna, about 1.3–1.4 mm.

Rostrum and palpi black. Antennae black throughout; flagellar segments oval to long-oval. Head dull black, sparsely pruinose.

Pronotum black, the anterior pretergites restrictedly yellow. Mesonotum uniformly black, the surface subnitidous. Pleura black, sparsely pruinose to produce a somewhat plumbeous appearance; metapleural region abruptly yellow; dorsopleural membrane black. Halteres with stem black, knob conspicuously light yellow. Legs uniformly black. Wings whitish subhyaline or with a very weak brownish tinge; stigma large, pale brown, inconspicuous; veins dark brown, *Sc* more yellowed. Venation: Sc_1 ending from about opposite the fork of *Rs* to near midlength of R_{2+3+4}, Sc_2 some distance from its tip; *r-m* at or shortly before the fork of *Rs*; R_2 transverse, very faint to virtually obsolete; cell *1st* M_2 long, subequal to vein M_3 beyond it; *m-cu* at near one-third to one-fourth the length of cell *1st* M_2.

Abdomen, including hypopygium, black throughout. Male hypopygium distinctive. Tergal region not well developed nor spinous. Basistyle simple, unarmed, the inner apical portion with a group of very long yellow setae from hyaline punctures; outer face of style with the setae small and scattered. Outer dististyle a strong simple glabrous rod, narrowed to the obtuse yellow apex, on mesal face before apex microscopically serrulate, including an outer stronger apiculate point. Inner dististyle a long straight arm, at apex bent upward into a lobe that is provided with strong setae; at base of this arm with a strong branch that is approximately two-thirds as long, from a dilated base, the surface of outer face and apex with strong scattered setae. Phall-

osome a blackened mass, the apex narrowed into an obtuse, more strongly darkened part.

Habitat.—Peru (Huanuco). *Holotype*, ♂, Sariapampa, in fog forest, altitude 3600 meters, May 4, 1946 (Woytkowski). *Paratopotype*, 1 ♂, May 11, 1946 (Woytkowski).

Superficially the present fly resembles species such as *Gnophomyia* (*Gnophomyia*) *maestitia* Alexander and relatives but is entirely distinct from all other black species having the knobs of the halteres yellow. The structure of the inner dististyle of the male hypopygium is distinctive.

Gnophomyia (Gnophomyia) adjusta sp. n.

General coloration black, the mesonotum subopaque by a weak bloom; antennae and legs black; halteres black, the knobs conspicuously bright yellow; wings with a strong brownish tinge, stigma not indicated; *Sc* short, Sc_1 ending about opposite the fork of *Rs*; cell *1st* M_2 long and narrow, subequal to vein M_4; male hypopygium with the median region of the caudal border produced into pale membranous tissue; outer dististyle blackened, twisted before the more yellowed obtuse apex; inner dististyle with unusually numerous setae.

Male.—Length, about 6.5 mm.; wing, 5.8 mm.; antenna about 1.5 mm.

Rostrum and palpi black. Antennae black throughout, the scape more pruinose; flagellar segments oval, the outer ones progressively shorter; verticils much longer than the segments. Head dull black; anterior vertex broad, the eyes relatively small.

Pronotum brownish black, the lateral ends and the anterior pretergites obscure orange yellow; an even more restricted brightening on the posterior pretergites before the wing root. Mesonotum black, the surface subopaque by a weak bloom. Pleura black, more pruinose ventrally, especially behind; meral region vaguely brightened. Halteres black, the knobs conspicuously bright yellow. Legs with the coxae black, more or less pruinose, the middle pair heavily so; remainder of legs black. Wings with a strong brownish tinge; stigma not indicated; veins dark brown. Venation: *Sc* short, Sc_1 ending about opposite the fork, Sc_2 about opposite two-thirds the length of *Rs*; *Rs* oblique, nearly straight, *r-m* close to its fork; vein R_2 faint, slightly oblique, at or beyond the fork of R_{2+3+4}; cell *1st* M_2 long and narrow, slightly widened outwardly, subequal in length to vein M_4; *m-cu* just before midlength of cell *1st* M_2.

Abdomen, including hypopygium, black. Male hypopygium with the tergite transverse, relatively long, the median region of the caudal border further produced into paler membranous tissue, as is common in a section of the subgenus; this is distorted and torn in the type and cannot be accurately described. Basistyle stout, blackened, without lobes. Outer dististyle a glabrous blackened rod, gently curved, twisted before the obtuse more yellowed apex. Inner dististyle with the apical portion a cylindrical tumid lobe, its tip obtuse; basal part lower and slightly more pointed, the margin of the notch microscopically roughened; surface of entire style with unusually numerous setae. Phallosome blackened, nearly cordate in outline, the obtuse apex more blackened.

Habitat.—Peru (Huanuco). *Holotype*, ♂, Sariapampa, in fog forest, altitude 3600 meters, May 8, 1946 (Woytkowski).

In its blackened body and legs, the present fly is superficially like various members of the *tristissima* group, such as *maestitia* Alexander, having the ninth tergite of the male hypopygium variously armed with spinous setae. From the structure of the male hypopygium, it is evident that it is closer to species such as *Gnophomyia* (*Gnophomyia*) *fessa* Alexander, *G.* (*G.*) *justa* Alexander, *G.* (*G.*) *lata* Alexander, *G.* (*G.*) *porteri* Alexander, and others, differing in the details of structure of the hypopygium, in the venation, and in the uniformly blackened legs.

Gnophomyia (Gnophomyia) pauciseta sp. n.

General coloration of thorax black, sparsely pruinose; knobs of halteres yellow; legs brownish black; wings with a weak brownish tinge; vein R_2 slightly oblique; male hypopygium with the tergite long, with numerous setae; mesal face of basistyle produced into a large obtuse lobe; outer lobe of inner dististyle with unusually few setae, these restricted to the outer third; phallosome broadly oval, the apex blackened, entire.

Male.—Length, about 7.5 mm.; wing, 7.5 mm.; antenna, about 1.6 mm.

Rostrum and palpi black. Antennae black throughout, of moderate length; flagellar segments subcylindrical, a little shorter than the verticils. Head dull black; eyes very large, the anterior vertex correspondingly reduced.

General coloration of thorax black, the surface opaque by a sparse pruinosity, the anterior pretergites restrictedly more brightened; humeral region of praescutum light gray pruinose, enclosing the black pseudosutural foveae; posterior borders of scutal lobes obscure yellow. Pleura somewhat paler across the dorsal sternopleurite, becoming pruinose behind, the metapleura yellow. Halteres infuscated, the knobs conspicuously yellow. Legs with the coxae dark brown; trochanters yellowish brown, the hind pair clearer yellow; remainder of legs dark brown to brownish black, the tibiae a trifle paler than the femora. Wings with a weak brownish tinge, the restricted prearcular field more yellowed; stigma long and very narrow, slightly darker brown, inconspicuous; veins brown, yellow in the prearcular field. Venation: Sc_1 ending immediately before the cephalic end of the slightly oblique R_2; *r-m* close to the fork of Rs; cell *1st* M_2 subequal in length to vein M_4, with *m-cu* just beyond one-fourth the length.

Abdomen, including hypopygium, black. Male hypopygium with the tergite relatively long, the length approximately one-third the transverse diameter or width; surface with relatively numerous setae, the lateral ones long and stout; median region of tergite produced into a broad flattened lobe, the apex rounded and membranous. Basistyle stout, its mesal face produced into a large obtuse lobe provided with setae. Outer dististyle a simple glabrous rod, the outer half more narrowed, gradually produced to the subacute tip; the style of one side only bears a single strong seta on outer face before apex. Inner dististyle with the outer lobe long, clavate, with unusually few setae, these restricted approximately to the outer third; the enlarged basal

part of style with relatively few setae. Phallosome broadly oval, the apex blackened, entire; aedeagus jutting beyond the apex of the major phallosomic structure as a slender rod, its apex capitate, yellow.

Habitat.—Peru (Huanuco). *Holotype*, ♂, Fundo Sinchono, altitude 1500 meters, August 5, 1947 (Schunke).

The present fly is most similar to species such as *Gnophomyia* (*Gnophomyia*) *flebilis* Alexander, *G.* (*G.*) *lata* Alexander, *G.* (*G.*) *perlata* Alexander, and others, differing especially in the structure of the male hypopygium.

Gnophomyia (Gnophomyia) persevera sp. n.

Mesonotum almost uniformly dark brown; antennae short; pleura with a brown dorsal stripe; halteres infuscated; wings with a weak brown tinge; veins delicate; Sc_1 ending shortly before the slightly oblique R_2; cell *1st* M_2 long and narrow, with *m-cu* at one-third its length; male hypopygium brownish black; tergite unusually narrow, unmodified, provided with sparse setae; no lobes on basistyle; phallosome oval, the apex narrowly emarginate.

Male.—Length, about 5.5 mm.; wing, 5.2 mm.; antenna, about 1.2 mm.

Female.—Length, about 6 mm.; wing, 6.5 mm.

Rostrum and palpi brownish black. Antennae relatively short, brownish black throughout; flagellar segments subcylindrical, the longest verticils exceeding the segments. Head dark gray, lighter gray on front and anterior vertex, the latter (in male) narrow, about one-half wider than the diameter of the scape, the eyes correspondingly large.

Pronotum orange-yellow above, darker on sides; pretergites paler yellow. Mesonotum almost uniformly dark brown, the praescutum more pruinose; lateral borders of scutal lobes obscure yellow, parascutella brown; pleurotergite dark brown on ventral portion, paling to yellow on dorsal half in male, uniformly darkened in female. Pleura with a broad dark brown longitudinal stripe, the ventral sclerites abruptly brownish yellow, clearer yellow behind; dorsopleural region narrowly yellow. Halteres infuscated, the base of stem narrowly yellow. Legs with the coxae yellow, the fore pair darker, the posterior coxae clear light yellow; trochanters yellow; femora obscure yellow, the tips more infuscated; tibiae and tarsi light brown, the outer tarsal segments passing into brownish black. Wings with a weak brownish tinge, the prearcular field more yellowed; stigma elongate, pale brown, only a little darker than the ground; veins very delicate, brown, more yellowed in the prearcular field. Venation: Sc long, Sc_1 ending shortly before the level of the cephalic end of the oblique semiobliterated R_2; Rs straight, *r-m* at its fork; cell *1st* M_2 long and narrow, subequal to or a trifle shorter than vein M_4, with *m-cu* at one-third its length.

Abdomen, including hypopygium, brownish black. Male hypopygium with the tergite unusually narrow, the transverse width fully five times the longitudinal dimension; caudal margin unarmed and not produced medially behind, as in related species; setae sparse and delicate, arranged virtually in a single row, this becoming double on the central third of the sclerite. Basistyle without lobes. Outer dististyle a glabrous darkened rod, narrowed gradually to the subacute tip. Inner

dististyle with the apical lobe nearly parallel-sided, at apex produced ventrad into a lobe; basal lobe moderately developed. Phallosome oval in outline, the apex narrowly emarginate, each lobe thus formed blackened at apex.

Habitat.—Peru (Loreto). *Holotype*, ♂, Cerro Azul, April 30, 1947 (Schunke).

Most nearly allied to species such as ***Gnophomyia*** (***Gnophomyia***) ***banksiana*** Alexander, *G.* (*G.*) ***subhyalina*** Alexander, and *G.* (*G.*) ***vilis*** Alexander, differing from all in the structure of the male hypopygium. The very narrow ninth tergite is noteworthy.

Gnophomyia (**Gnophomyia**) **mediotuberculata** sp. n.

Mesonotum chiefly brown, the humeral region of praescutum yellow; pleura yellow with a broad conspicuous brownish black longitudinal stripe across the dorsal sclerites; knobs of halteres brownish black; wings with a weak grayish tinge; stigma brownish yellow, small and scarcely evident; vein R_2 distinct, transverse; cell *1st* M_2 small, *m-cu* at near midlength; male hypopygium with the tergite transverse, its posterior portion extended into a long depressed-flattened lobe; on surface of tergite with a tubercle bearing several strong setae; outer dististyle flattened and twisted; inner dististyle produced laterad at tip into a short point; phallosome emarginate medially, the two lateral lobes thus formed blackened and microscopically roughened.

Male.—Length, about 8 mm.; wing, 6.5 mm.; antenna, about 1.8 mm.

Female.—Length, about 8 mm.; wing, 7 mm.

Rostrum and palpi black. Antennae with the scape brown, pedicel testaceous yellow, flagellum dark brown; flagellar segments long-subcylindrical, the longest verticils exceeding the segments. Head brownish gray, the orbits clearer gray; eyes large, the anterior vertex (male) relatively narrow, apparently less than three times the diameter of the scape.

Mesonotum chiefly brown, the humeral and lateral portions of praescutum yellow, pseudosutural foveae blackened; posterior lateral portions of scutal lobes and the narrow posterior border of the scutellum obscure yellow; anterolateral parts of mediotergite yellowed. Pleura yellow, with a broad conspicuous brownish black longitudinal stripe extending onto the pteropleurite. Halteres short, brownish black, the basal half of stem yellow. Legs with the coxae and trochanters yellow; femora and tibiae yellow, the tips more infuscated; tarsi brown, the basitarsi paler. Wings with a weak grayish tinge; stigma small and scarcely indicated, brownish yellow, not crossing vein R_{1+2} behind; veins brown, more brightened in the stigmal and prearcular fields. Venation: Sc_1 ending opposite R_2, Sc_2 just beyond the level of the fork of *Rs*; *r-m* at fork of *Rs*; vein R_2 distinct, transverse; cell *1st* M_2 relatively small, shorter than any of the veins beyond it, the second section of vein M_{1+2} less than one-third the outer section in male, somewhat longer in female; *m-cu* at near midlength of cell *1st* M_2; cell *2nd A* broad, the vein gently arcuated.

Abdominal tergites brownish black, sternites yellow; hypopygium, including tergite and basistyle, yellow, the dististyles darkened. Male hypopygium with the tergite transverse, the posterior portion produced

caudad into a long depressed-flattened extension, the rounded apex with microscopic setulae; on surface at midline of tergite with a rounded tubercle bearing about ten strong setae. Basistyle stout, the mesal face at near midlength produced into a pale fingerlike lobe. Outer dististyle a flattened twisted rod, the mesal margin near base microscopically toothed or roughened. Inner dististyle about two-thirds as long, at apex produced laterad into a blunt point. Phallosome with the lobe of either side blackened, the surface microscopically roughened; tip of aedeagus jutting caudad beyond the central emargination.

Habitat.—Peru (Loreto). *Holotype*, ♂, Contamana, Upper Ucayali River, May 22, 1947 (Schunke). *Allotopotype*, ♀, pinned with type.

Most like species such as ***Gnophomyia*** (***Gnophomyia***) ***apicularis*** Alexander, ***G.*** (***G.***) ***subapicularis*** Alexander, and allies, differing most evidently in the structure of the male hypopygium, especially the tergite, dististyles, and phallosome.

ANNALES UNIVERSITATIS MARIAE CURIE-SKŁODOWSKA.—This publication of The University Maria Curie-Skłodowska, Lublin, Poland, is divided into six sections, of which Section C is devoted to the Biological Sciences. The plan, according to the statement of the editors, is to publish 240 to 400 printed pages in each section of each annual volume, and to take care of longer articles in supplements. Section C, Volume I (1946–1947), contains 9 numbers, Volume II (1947), 13 numbers, and Volume III (1948), apparently 14 numbers. There have been three supplements, all dated 1947. The following papers deal with arthropods: N. Nicewicz, W. Nicewicz, and R. Kowalik, "Description of microorganisms supported on the bacteriological analysis in the alimentary tracts of the bed bug, house fly and cockroach," Vol. I, No. 2; Jarosław Urbański, "Les Isopodes du district de Poznań," Vol. I, No. 3; Konstanty Strawiński, "Contribution to the biology and occurrence of *Neurotoma nemoralis* L. (*Hymenoptera-Pamphiliidae*) in Poland," Vol. II, No. 4; Urbański, "Contributions à la connaissance des zoocecidies des environs de Gdynia," Vol. II, No. 6; Urbański, "*Aeschna subarctica* Walker (Odonata Aeschnidae) dans le district Kartuzy," Vol. II, No. 10; Urbański, "Notes odonatologiques de la Bulgarie," Vol. II, No. 11; Hieronim Jawłowski, "Studies on the insects brain," Vol. III, No. 1; Urbański, "Critical review of dragon-flies (Odonata) of Poland," Vol. III, No. 11; and Stanisław Jakubisiak, "Ants in the environments of Przybyszewo (South Masovia), ecological study," Vol. III, No. 12. Supplement III is a "History of Zoology in Poland till 1918, parts I and II," by Gabriel Brzek.

An occasional article is in English (notably Jawłowski's "Study of the insect brain") or French; most are in Polish, with an English or French summary which may range from one that is dismayingly brief to one that almost amounts to a translation. The paper is of reasonably good quality; the print and the reproduction of drawings, color plates, and photographs are quite satisfactory. The articles seem to represent, at least for the most part, substantial contributions to science. The loss caused by destruction and dissipation of energy resulting from the war is evident as one looks through the articles, and one must admire the courage of a people who have produced work of this quality under such unfavorable circumstances. An example of this is to be found in the studies of ants by Jakubisiak, which the author carried on as a displaced person during the war years.—M. T. J.

BOOK NOTICE

BIOCHEMICAL EVOLUTION, by MARCEL FLORKIN. Edited, translated, and augmented by Sergius Morgulis. vii+157 pp., 24 fig. The Academic Press, New York. 1949. Price, $4.00.

During the past few decades there has developed among systematic zoologists and students of evolution, a growing realization that the concept of the species and its genetic relation to other species must be biological rather than primarily morphological in philosophy, and that morphologic differences and similarities among and between species usually have true validity only when they reflect, or are associated with, more profound biological differences and similarities. By extension, then, our concepts of evolution, as conceived primarily from the classical morphologic criteria, must be tested from the aspect of the progression of biological changes in general rather than simply on the basis of the progression of morphologic changes. The most fundamental of the biological changes are those which may be designated as biochemical. *Biochemical Evolution* is a refreshing, condensed inventory and analysis of biochemical facts and philosophy as they relate to evolution and phylogeny. The status of the biochemical approach to the study of evolution and phylogeny is well described by the author: "The study of biochemical characteristics depends upon techniques which frequently are complicated, and such a study is more difficult to accomplish than direct observation of morphological characters. Nevertheless, had naturalists started from these rather from morphological observations, they would have been bound to conceive the idea of evolution of animals. They could not have failed to recognize the phenomena of orthogenesis and adaptation, and they would have discovered biochemical characteristics on the basis of which to classify species into more or less extensive groups. Moreover, this classification, as far as our actual knowledge permits such a comparison, would be identical with the system elaborated by Cuvier and his collaborators. . . . To concede that the classification of morphological groups conforms to a biochemical classification is to favor the idea that morphological and biochemical characteristics are linked together and that both are governed by the same determinism. This offers an argument for the thesis that in the last analysis evolution is directed by biochemical phenomena." (p. 120.) Of particular interest to entomologists and zoologists in general will be the author's concepts of orthogenesis. He presents data for recognition of parallel orthogenetic series in such phenomena as proteinemia, protein-sugar or combined sugar content of blood, oxyphoric and buffer capacity of blood, digestion, protein metabolism, purine metabolism, and ammonemia. Likewise of interest are his "systematic characters" for certain taxonomic groups. For example, the insects are thus characterized by the relatively high amino acid level in the blood, relatively high concentration of uric acid in the blood, and high indices for magnesium and phosphate.

The book is, in general, refreshing and stimulating although there are occasional repetitions, which, by careful planning, might have been eliminated. Also there are some rather categorical and unqualified generalizations which, in light of the present status of our knowledge, may be somewhat premature. For example, it is stated that chitin unimpregnated with salts is "a systematic characteristic of the class of insects." (p. 118.) Wigglesworth (*The Principles of Insect Physiology*, Methuen, London, 1939, p. 20), cites several exceptions. Similarly it is stated (p. 100) that invertebrate animals are "completely insensitive to the action of thyroxine." This seems somewhat precarious at the present time. (See Goldsmith, *Ann. New York Acad. Sci.* 50(5): 294–295, for summary.) However, to avoid errors of generalization in condensing material of this type is difficult. There are some debatable choices of terms and some instances of obscure expression; these are presumably the virtually inevitable consequences of translation. The number of typographical errors is not unusual for a first edition. These criticisms are in no way intended to detract from the important philosophical contributions for which the reviewer has the greatest enthusiasm. *Biochemical Evolution* presents a synthetic philosophy worthy of the attention of all aspects of biology.—DONALD S. FARNER.

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PRINTED IN THE UNITED STATES OF AMERICA
THE SPAHR & GLENN COMPANY, COLUMBUS, OHIO